

Резюмета

на научноизследователските трудове на английски език на

гл. ас. д-р инж. **Милена Димитрова Иванова**

за участие в конкурс за академична длъжност „Доцент“, в професионално направление 5.4 Енергетика по научна специалност „Електротехнически материали и кабелна техника“, към катедра „Електроенергетика“ при Електротехнически факултет на Технически университет-Варна,

обявен в ДВ бр.4/ 13.01.2023г.

Опис:

Резюмета по показател В.4 - хабилитационен труд – научни публикации в издания, които са реферирани и индексирани в световноизвестни бази данни с научна информация.....4

[1] Barudov, E., Ivanova, M. “Investigation of electric and magnetic fields generated by a system for formation of high voltage discharge process in liquid based on capacitive energy storage,” in 18th Annual General Assembly of the International Association of Maritime Universities - Global Perspectives in MET: Towards Sustainable, Green and Integrated Maritime Transport, IAMU 2017, 2017, vol. 1, pp. 293–300, ISBN 978-954899196-4 5

[2] Ivanova, M. “Regression analysis of experimental data for electrical parameters of water at a high voltage pulse discharge”, in 2019 16th Conference on Electrical Machines, Drives and Power Systems, ELMA 2019 – Proceedings, June 2019, pp.595-599, ISBN 978-172811413-2, DOI 10.1109/ELMA.2019.8771494..... 6

[3] Georgiev, G., Ivanova, M., Dimitrova, R., Rangelov, Y. “Polymeric composite insulators for overhead power lines. A review of in-service damages and diagnostic approaches”, in 2021 17th Conference on Electrical Machines, Drives and Power Systems, ELMA 2021 – Proceedings, ISBN: 978-166543582-6, DOI: 10.1109/ELMA52514.2021.9503054 7

[4] Barudov, E., Ivanova, M. “Study of conductive textile fabrics for protection against high-frequency electromagnetic radiation”, in 2021 13th Electrical Engineering Faculty Conference, ISBN 978-166544192-6, DOI 10.1109/BulEF53491.2021.9690835 8

[5] Dimitrova, R., Yordanova, M., Vasileva, M., Ivanova, M. “Experimental determination of soil electrical parameters for the creation of a computer model of a grounding system for lightning protection”, Int. J. Reason. Intell. Syst., vol. 9, no. 2, pp. 101–113, 2017, ISSN 17550556, DOI 10.1504/IJRS.2017.088652..... 9

[6] Ivanova, M., Dimitrova, R. “Measurement of electrical parameters of soils on the territory of the Republic of Bulgaria in reference to more precise dimensioning of earthing installations of electrical power objects”, in 2019 11th Electrical Engineering Faculty Conference, BulEF 2019, DOI: 10.1109/BulEF48056.2019.9030780, ISBN: 978-172812697-5..... 10

[7] M. Yordanova, M. Vasileva, R. Dimitrova, and M. Ivanova, “A methodology for determining the maximum touch voltage in the grounding grids considering the impulse resistance”, in 2016 19th International Symposium on Electrical Apparatus and Technologies, SIELA 2016, 2016, pp. 376–379, ISBN 978-146739522-9, DOI 10.1109/SIELA.2016.7543067 11

[8] Dimitrova, R., Vasileva, M., Yordanova, M., Ivanova, M. “Simulation model of unsymmetrically-shaped grounding grids for investigation of the touch voltages during lightning stroke,” in 2018 20th International Symposium on Electrical Apparatus and Technologies, SIELA 2018 - Proceedings, 2018, pp. 103–106, Electronic ISBN:978-1-5386-3419-6, DOI: 10.1109/SIELA.2018.8447111 12

[9] Rangelov, Y., Georgiev, D., Georgiev, G., Kamenov, Y., Ivanova, M. “Methodological issues of soil thermal properties survey during HV cable line predesign phase”, in 2020 IEEE 12th Electrical

Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, Conference Proceedings, ISBN 978-172819439-4. DOI: 10.1109/BulEF51036.2020.9326062 13

[10] Georgiev, D., Georgiev, G., Rangelov, Y., Ivanova, M., Dimitrova, R., Hadzhidimov, I. “A study on the correlation between soil thermal and electrical resistivity for HV cable road pre-design purposes”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, ISBN 978-172819439-4. DOI: 10.1109/BulEF51036.2020.9326077 14

Резюмета по показател Г.7 - научни публикации в издания, които са реферирани и индексирани в световноизвестни бази данни с научна информация.....15

[1] Panov, E., Ivanova, M., Barudov, E. “Study of the electrical characteristics of autotransformer discrete alternating voltage regulators with R-L loads,” in 2019 16th Conference on Electrical Machines, Drives and Power Systems, ELMA 2019 – Proceedings, June 2019, pp.321-325, ISBN 978-172811413-2. DOI 10.1109/ELMA.2019.8771651 15

[2] Ivanova, M., Panov, E., Barudov, E. “Exploration of the efficiency of autotransformer discrete alternating voltage regulators”, in 2020 IEEE International Conference Automatics and Informatics (ICAI), 1-3 Oct. 2020, Varna, Bulgaria, Electronic ISBN:978-1-7281-9308-3. DOI: 10.1109/ICAI50593.2020.9311348, 16

[3] Barudov, E. Ivanova, M. “Study of electromagnetic fields in buildings in the vicinity of a marine radar installation”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, DOI: 10.1109/BulEF51036.2020.9326012 17

[4] Panov, E., Barudov, E., Dimitrov, D., Ivanova, M. “Protection regimes and electrical quantities in autotransformer alternating voltage regulators”, in 2020 21st International Symposium on Electrical Apparatus and Technologies, SIELA 2020 – Proceedings, June 2020, DOI: 10.1109/SIELA49118.2020.9167144, ISBN: 978-172814346-0 18

[5] Panov, E., Ivanova, M., Barudov, E. “Study of the parameters of an autotransformer discrete alternating voltage regulators considered as a two-port”, in 2021 17th Conference on Electrical Machines, Drives and Power Systems, ELMA 2021 – Proceedings, pp.377-380, ISBN 978-166543582-6. DOI 10.1109/ELMA52514.2021.9503020 19

[6] Panov, E. Barudov, E., Ivanova, M. “Exploration of the electric processes in discrete alternating step-voltage regulators,” in 2018 20th International Symposium on Electrical Apparatus and Technologies, SIELA 2018 - Proceedings, 2018, pp. 314–317, ISBN 978-153863419-6. DOI 10.1109/SIELA.2018.8447122 20

[7] Ivanova, M., Dimitrova, R., Filipov, A. “Analysis of power outages and human errors in the operation of equipment in power grids”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, Conference Proceedings, ISBN 978-172819439-4, DOI: 10.1109/BulEF51036.2020.9326058 21

[8] Ivanova, M., Yordanova, M., Dimitrova, R. “Evaluation of the step voltages for grounding grids at lightning strikes”, in 2020 21st International Symposium on Electrical Apparatus and Technologies, SIELA 2020 – Proceedings, June 2020, DOI: 10.1109/SIELA49118.2020.9167157, ISBN: 978-172814346-0 22

[9] Mehmed-Hamza, M., Filipov, A., Ivanova, M. “Research and analysis of faults in medium voltage distribution grids”, in 2021 56th International Scientific Conference on Information, Communication and Energy Systems and Technologies, ICEST 2021 – Proceedings, pp. 227-230, ISBN 978-166542887-3. DOI 10.1109/ICEST52640.2021.9483457 23

Резюмета по показател Г.8 - научни публикации в нереперирани списания с научно рецензиране или в редактирани колективни томове.....24

[1] Dicheva, M., Barudov, E. “Expert evaluation of the quality of the electricity and the power supply”, Proceeding from the Annual university conference of the National Military University “Vasil Levski”, Veliko Tarnovo, 2009, vol.6, pp. 173-181, ISSN 954-753-035-6. (In Bulgarian) 25

[2] Barudov, S., Dicheva, M. “E-learning in the Electrical Engineering Faculty at the Technical University of Varna. Practice and problems.”, in 3rd national conference with international participation in

e-learning in higher education, Proceedings, vol. 1, Dimitar A. Tsenov Academy of economics, Svishtov, 2009, pp. 297-304, ISSN: 978-954-23-0427-2. (In Bulgarian)..... 26

[3] Barudov, S., Ivanova, M. “Discharge element with transverse high-frequency excitation”, in XLVI Int. scientific conference on information, communication and energy systems and technologies ICEST 2011, 2011, Nis, vol.3, p.959-962, ISBN: 978-86-6125-033-0..... 27

[4] Barudov, S., Dimitrova, R., Ivanova, M. “Single-circuit and double-circuit regulating apparatus for gas discharge element”, in XLVII Int. scientific conference on information, communication and energy systems and technologies ICEST 2011, 2011, Nis, vol.3, p.956-958, ISBN: 978-86-6125-033-0.. 28

[5] Barudov, S., Ivanova, M. Dimitrova, R. “Study of the commutation capabilities of a controllable air discharger in circuit of high-voltage pulse discharge”, Annual proceedings of the Technical University of Varna, 2011, Bulgaria, vol. I, p.15-20, ISSN: 1311-896X. 29

[6] Dimitrov, D., Dimitrova, R., Ivanova, M., Vassileva, M. “Analysis and comparative evaluation of energy effective drivers for LED with autonomous power supply”, in 3rd International congress “50 years Technical university of Varna”, 2012, Varna, vol. III, p.110-115, ISBN 978-954-20-0552-0.30

[7] Dimitrov, D., Dimitrova, R., Ivanova, M., Vassileva, M. “Study of some influences of the internal parameters of specialized integrated circuits for LEDs”, in 3rd International congress “50 years Technical university of Varna”, 2012, Varna, vol. III, p.116-121, ISBN 978-954-20-0552-0. 31

[8] Ivanova, M., Barudov, S. “Comparative analysis and modelling of a high voltage periodically attenuating discharge in liquid in a circuit with two discharge gaps”, Marine scientific forum, 16-17 may, 2013, Nikola Vaptsarov Naval Academy, pp.110-117, ISSN 1310-9278. (In Bulgarian)..... 32

[9] Ivanova, M. “Study of the energy characteristics and the temperature influence on the liquid medium resistance during the formation of a high voltage discharge”, in L international scientific conference on information, communication and energy systems and technologies – ICEST, 2015, Sofia, p.292-295, ISBN 978-619-167-182-3. 33

[10] Vasileva, M., Dimitrova, R., Yordanova, M., Ivanova, M. “Model scheme of the earthing system of electrical power substations for wave processes study”, in 14th International conference on electrical machines, drives and power systems, Proceedings, 2015, Varna, p.114-117, ISSN 1313-4965.

34

[11] Yordanova M., Dimitrova R., Vasileva M., Ivanova M. “Regression analysis of experimental data for the soil electrical characteristics considering humidity and frequency”, in 1st International Conference “Applied Computer Technologies” ACT 2018, 21-23 June, Ohrid, Macedonia, Proceedings, pp.79-82, ISBN 978-608-66225-0-3. 35

[12] Ivanova, M., Barudov, E. “Study of the energy characteristics of a system for generation of high-voltage discharge pulses for water treatment with the usage of a discrete alternating voltage regulator”, in IST International conference of Marine Engineering, 21-23 Nov. 2018, NVNA Varna, Bulgaria, pp.63-67, ISBN 978-619-7428-31-5 (pdf)..... 36

Резюмета по показател В.4 - хабилитационен труд – научни публикации в издания, които са реферирани и индексирани в световноизвестни бази данни с научна информация

- [1] Barudov, E., Ivanova, M. “Investigation of electric and magnetic fields generated by a system for formation of high voltage discharge process in liquid based on capacitive energy storage,” in 18th Annual General Assembly of the International Association of Maritime Universities - Global Perspectives in MET: Towards Sustainable, Green and Integrated Maritime Transport, IAMU 2017, 2017, vol. 1, pp. 293–300, ISBN 978-954899196-4

Various technological applications require formation of a high voltage discharge pulse in liquid medium. The process is accompanied with generation of UV radiation, production of chemically active species in the medium, intensive increase of the temperature of the discharge channel, generation of shock waves, etc. The last are caused by the release of a large amount of energy especially at the beginning of the discharge process.

The experimental system used for generation of a high voltage pulse discharge is based on capacitive energy accumulation. The formation of the pulse in the liquid considering the specifics of the process in such medium also affects on the processes in the electrical circuits of the device – loading of the elements, creating electromagnetic disturbances in the power supply system, generation of electromagnetic field around the device.

The paper is dedicated to investigation of a system with capacitive energy storage for generation of a high voltage periodically attenuating pulse discharge. The purpose is to be measured the external electric and magnetic fields generated during the charging and discharging processes near the system for assessment of the device electrical safety for the personnel.

The values of the electric field strength E and magnetic flux density B are measured during the charging and discharging processes near the device elements (transformers and discharge gaps). Evaluation of the compliance of the measured values with respect to the norm values defined by (Directive 2013/35/EU, 2013) is done. Safe work conditions are set at the device operation.

The received values for the magnetic flux density B for both of the transformers are much higher (approximately by 70% for the highest values of the voltage U_c) than the values measured in the charging process. The generated electric field (E) is 3÷5 times weaker than the generated one in the charging process of the capacitor battery. The increase of the magnetic field can be explained by the generation of a magnetic pulse in the discharge process due to the high amplitude of the discharge current. The measured values are again under the low ALs for the electric and magnetic fields. Measurements near the metal water container when a discharge pulse occurs are also performed. Despite the high frequency of the discharge pulse, no significant data for the generated electric or magnetic field is recorded due to field shielding by the container.

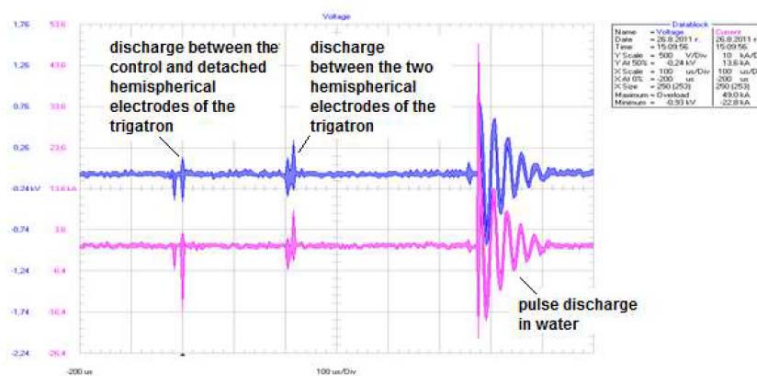


Fig. 4. Discharge process at $C=2 \mu\text{F}$ and $U_c=11\text{kV}$ (upper curve – discharge voltage, lower curve – discharge current).

[2] Ivanova, M. “Regression analysis of experimental data for electrical parameters of water at a high voltage pulse discharge”,, in 2019 16th Conference on Electrical Machines, Drives and Power Systems, ELMA 2019 – Proceedings, June 2019, pp.595-599,ISBN 978-172811413-2, DOI 10.1109/ELMA.2019.8771494

Many physical and chemical processes are observed in water under the formation of high voltage discharges, which depend on the characteristic of the system for generation of high voltage discharge (HVD) pulses and the physical properties of the liquid medium. The processes, which develop in the liquid medium at arising a HVD, are highly dynamic and depend on different factors such as the recombination of current carriers, the drift movement of current carriers, scattering of current carriers outside the plasma channel at the expense of a thermal diffusion and others. The duration of the different processes most commonly depends on the structure of the medium, external factors (temperature, parameters of the electric field, elements of the discharge circuit and spatial geometry of plasma channel). Their mutual influence is difficult to analyze and therefore requires experimental research.

Considering the dynamics of these processes, the determination of the electrical parameters of the water is necessary for the practical usage of the electrical discharges in water in different technological applications.

The aim of the present paper is to analyze experimental data for the water resistance change during the formation of a high-voltage discharge pulse regarding the influence of some electrical parameters of the system based on capacitive energy storage and the water temperature. During a high voltage periodically attenuating pulse discharge in water, the main part of the energy is released in the first half-wave of the process (> 80 %). So, the research is focused on this time interval of the discharge process.

The separate influence of the three parameters U_c (voltage, to which the capacitor battery is charged to), C (capacitance of the capacitor battery) and T (water temperature) on the water resistance in the first half period of the discharge process was investigated in order to suggest more accurate mathematical model for describing the complex relationship $R = f(U_c, C, T)$. Regression statistics for determination of the accuracy of the model and the significance of the members in the equation is used. Good correlation between the true values of the water resistance and its estimated values by the regression equation is achieved (96,56 %).

A simplified mathematical description for determination of the water resistance is proposed, which has also shown good correlation (94,9%) with the results from the measurements.

The proposed model for calculation of the water resistance can be used in the development and sizing of the charging and discharge circuits in such systems for generation of high voltage pulse discharges and investigation of the processes in them.

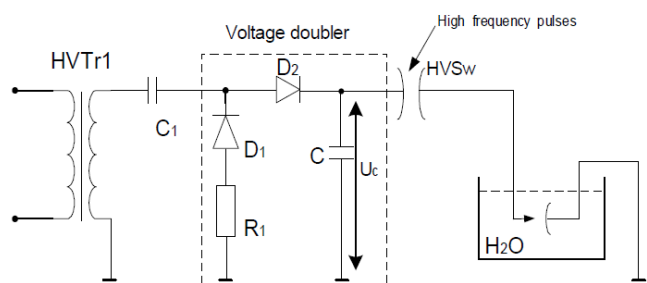


Fig. 1. Device for formation of high voltage pulse discharges in water with capacitive energy storage. [4]

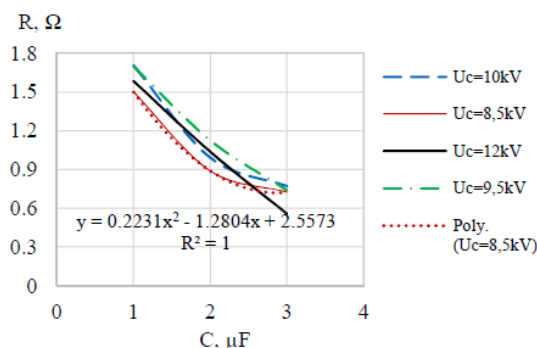


Fig.6. Resistance of the liquid medium for the first half-period of the discharge process depending on the capacitance C at water temperature $T = 16^\circ\text{C}$.

[3] Georgiev, G., Ivanova, M., Dimitrova, R., Rangelov, Y. “Polymeric composite insulators for overhead power lines. A review of in-service damages and diagnostic approaches”, in 2021 17th Conference on Electrical Machines, Drives and Power Systems, ELMA 2021 – Proceedings, ISBN: 978-166543582-6, DOI: 10.1109/ELMA52514.2021.9503054

Polymeric composite insulators have been used worldwide from decades. Various cases of their failures attracted attention to the disadvantages of the design and to the necessity of tools and methods for diagnostics of their condition and remaining service life. The most important thing for the personnel responsible for the maintenance is to have effective tools and knowledge to determine the insulators condition. Up to present, there is no generally accepted methodology for monitoring and timely detection of developing defects of polymeric composite insulators. This necessitates the search for methods for diagnostics of developing defects, applicable to the maintenance groups of power grids operators.

The paper presents a review of the current experience on the maintenance of polymeric composite insulators and aims to highlight the existing diagnostic methods that are suitable for field inspection. Another purpose of the publication is to outline guidelines for development in the field of in-service diagnostics. The types of damages, the causes and the factors leading to their occurrence are presented. Various methods for diagnostics and assessment of their applicability are considered. The corresponding conclusions have been made. A case study of an in-service aged insulator is presented with the usage of methods that rely on measurement of the insulation resistance and the dielectric losses. The corresponding conclusions have been made.

The known diagnostic methods are classified in the paper from the point of view of maintenance organization. The practical suitability of the diagnostic methods is determined by their ability to detect timely defects, in case of which it is inadmissible to leave the insulator in service until the next scheduled inspection. Such decision requires both list of the types of the inadmissible defects and quantitative measures for assessment of the severity of each defect, which is not a new kind of evaluation.

The conclusion drawn from the review of the available sources of information on polymeric composite insulators for overhead power lines outline the path for development of this type of insulators from the design to the end of their service life. The authors considered that it is important to be paid special attention to the following aspects: 1) As far as the basic methods for initial diagnostic are visual, the creation of an illustrated manual to be distributed to electricity power grid operators is required. 2) Because of the limitations of the visual methods, there is a need to use cost effective and reliable methods that are able to detect defects under the insulator housing. Such methods have to be appropriate for field application and to rely on portable equipment. Promising are the well-studied diagnostic methods applied so far in the maintenance of electrical machines, apparatus and cables and capable to detect hidden surface tracking, voids and moisture – for example the methods that rely on measurement of the insulation resistance or on the measurement of the dielectric loss angle ($\tan(\delta)$).

The results obtained by the authors in the case study of service aged insulators are a positive evidence of the ability of such methods to detect changes that visual methods would miss. Diagnostics by measuring $\tan(\delta)$ looks promising if prior the measurement the insulator is wetted.



Fig. 1. Damaged polymeric composite insulator:
a) brittle fracture, b) wetted surface for assessment of the hydrophobicity

[4] Barudov, E., Ivanova, M. “Study of conductive textile fabrics for protection against high-frequency electromagnetic radiation”, in 2021 13th Electrical Engineering Faculty Conference, ISBN 978-166544192-6, DOI 10.1109/BuEF53491.2021.9690835

There are various methods for shielding electromagnetic radiation, but they are sometimes inapplicable due to the configuration of the premises, the location of the transmitters and receivers and the requirements of the operating equipment. A modern method to solve this problem is by using flexible screens made of fabrics impregnated with specific metals (conductive textile fabrics, metalized textile fabrics), which provide protection at different source configurations, frequency and signal strength.

The aim of the work is a comparative analysis of the changes of the electromagnetic field parameters at standard household configurations (with different frequency) as EMF sources and shielded by protective factory-produced flexible screens. Two types of conductive textile fabrics have been tested (with silver and copper-nickel fibers) with two radio frequency sources. A comparison of the results with valid international standards has been also made. The corresponding conclusions regarding the shielding effectiveness of the two samples have been made.

The objects of the research are two samples of conductive fabrics: silver coated knitted (mesh) fabric, Model: SILVER36 (Silver fiber 100 %) and a copper-nickel composite plated polyester fabric. Two sources of EMF with radio frequency, which are daily used in a household, were chosen: 1) Xiaomi MI Wi-Fi Range extender Pro, Model: R03 – $f = 2400 \div 2483.5$ MHz; 2) mobile phone Samsung Galaxy A52 4G 2021 (LTE-Advanced), switched to call mode for the measurements.

The measurements of the parameters of the generated EMF field with radio frequency of the Wi-Fi Range extender were conducted for the following cases: 1) operating unshielded source; 2) shielded source with fabric 1; 3) shielded source with fabric 2. The measurements of the parameters of the generated EMF field of the mobile phone Samsung Galaxy A52 were conducted for the following cases: 1) operating unshielded source in call mode; 2) operating unshielded source in call mode and shielded measuring device with fabric 1; 3) operating unshielded source in call mode and shielded measuring device with fabric 2. The difference between the measurement cases for the two sources is due to the fact that when the mobile phone is shielded, it goes out of range and no measurements can be made. That is why the shielding is done over the EMF meter.

Both studied samples of metallized fabric for EMF protection can be evaluated to the highest class without grounding, providing protection against EMF generated by general purpose devices operating with radio frequency, according to Table I ($SE > 30$ dB in the area next to the source). For the studied variants, sample 1 (silver) shows better shielding efficiency (SE) due to the specificity of the material. In the presence of sources of EMF with higher parameters than the norms, with the specifics of the emitters that do not allow the use of classic protecting screens, it is advisable to apply flexible screens on a person or the area to be protected. Based on the performed measurements and the obtained results, a selection of the protective material can be made and a safe distance from the EMF source can be determined after its application. In shielding applications, it should be considered that metallized fabrics must be grounded to achieve better shielding effect. Otherwise, they could act as an antenna for RF EMFs.

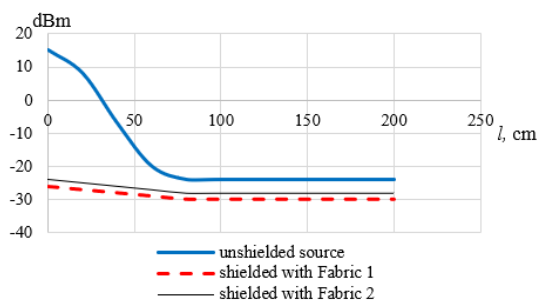


Fig. 10. Power of the EMF field, generated by source 2 for the three cases

TABLE V. CALCULATED SPECIFIC ABSORPTION RATE (SAR) FOR UNSHIELDED AND SHIELDED SOURCES 1 AND 2.

Distance to the source, cm	Source 1 SAR, W/kg dry / wet skin			Source 2 SAR, W/kg dry / wet skin		
	Unshielded (*10 ⁻³)	Shielded with fabric 1 (*10 ⁻³)	Shielded with fabric 2 (*10 ⁻³)	Unshielded (*10 ⁻³)	Shielded with fabric 1 (*10 ⁻³)	Shielded with fabric 2 (*10 ⁻³)
0	646/699	2.7/2.93	3.57/3.87	452/490	2.48/2.69	8/8.67
20	90.1/97.8	2.5/2.71	2.73/2.96	98.9/107.2	2.01/2.18	5.55/6.02
40	8.59/9.32	2.23/2.42	2.48/2.69	2/2.17	1.22/1.32	1.59/1.72
60	0.98/1.06	2.13/2.31	2.44/2.65	0.28/0.3	1.22/1.32	1.49/1.62
80	0.16/0.18	1.9/2.06	2.41/2.61	0.025/0.027	1.05/1.13	1.46/1.58
100	0.16/0.13	1.6/1.73	2.23/2.42	0.025/0.027	0.89/0.097	1.38/1.49

- [5] Dimitrova, R., Yordanova, M., Vasileva, M., Ivanova, M. “Experimental determination of soil electrical parameters for the creation of a computer model of a grounding system for lightning protection”, *Int. J. Reason. Intell. Syst.*, vol. 9, no. 2, pp. 101–113, 2017, ISSN 17550556, DOI 10.1504/IJRIS.2017.088652

The paper presents multifactor experimental studies for determining the apparent soil resistivity and the dielectric permittivity depending on the frequency of the electromagnetic field, the multilayered structure, moisture content and density of the soil. The gravimetric method for considering the soil moisture during the experimental research was chosen. The received experimental results were statistically processed and a mathematical modeling of the controlled parameters was performed considering the specifics of the examined soil. These analytically obtained results of the dependencies would contribute to more precise sizing of the grounding systems and could be used for creation of accurate simulation models for study of wave processes in them.

A direct lightning stroke over an object leads an impulse current to flow through the grounding elements. High frequency processes develop in the soil area around them. The apparent soil resistivity and the relative dielectric permittivity must be precisely determined for the respective frequency in order to be created a correct model of the grounding system for study of the wave processes. In the literature, there is data for the soil resistivity and the relative permittivity ϵ_r at different frequencies of the electromagnetic field. However, a model for defining these parameters at random frequency is not suggested. Since the soil resistivity directly affects the grounding resistance, it is necessary to be accurately determined depending on the frequency of the current flowing through the grounding rod and the soil. Such research has been conducted and published by other authors, but for a significantly narrower frequency range from 12 Hz to 100 kHz.

Samples of the soil from the residential area around the city Varna have been taken. The studies have been done for the purpose of a development of a methodology for preliminary investigation in design and construction of electrical power objects. The resultant mathematical expression of the dependencies of the apparent soil resistivity and the relative permittivity from the frequency of the electric field (from 1 kHz to 1 MHz), obtained by a computer program Grapher, is used for different moisture content and density of the samples. This equation can be used in the calculation of the apparent soil resistivity and the grounding resistance value for a certain frequency.

From the conducted research it is noticed that at increasing the soil density, the apparent soil resistivity ρ_v and the relative dielectric permittivity ϵ_r decrease. At higher moisture content of the soil, ρ_v decreases, while ϵ_r rises. When increasing the frequency of the electromagnetic field, the values of both investigated parameters decrease. This can be explained by the change of the electrical parameters of the soil from the frequency and the complex character of the soil dielectric permittivity at alternating electromagnetic field. The great variety of the values of ρ_v and ϵ_r determines the need for preliminary investigation by taking samples before starting to design a grounding system.

For the purpose of sizing of grounding systems while considering the pulse processes in the soil when injecting lightning pulse current, a mathematical expression for the relations of ρ_v and ϵ_r from the frequency has to be defined by the experimental results.

The received mathematical expressions of $\epsilon_r(f)$ is used for calculation of the capacitance of the grounding system, which is necessary for creating a model scheme of the installation for study of wave processes in it. The obtained experimental results for the electrical characteristics of the soil with the usage of the dielectric method confirm the results, published in other researches. This gives a basis for extended research and examination of samples in the presence of layered soil.

[6] Ivanova, M., Dimitrova, R. “Measurement of electrical parameters of soils on the territory of the Republic of Bulgaria in reference to more precise dimensioning of earthing installations of electrical power objects”, in 2019 11th Electrical Engineering Faculty Conference, BuIEF 2019, DOI: 10.1109/BuIEF48056.2019.9030780, ISBN: 978-172812697-5

The building of grounding installations of electrical power objects is mandatory to ensure the normal operation of the facilities and the safe work of the personnel. In order to develop a correct model of a grounding installation for the study of wave processes and to determine the parameters of the efficiency of the installation, the electrical characteristics of the soil must be correctly determined. The specific volume resistance (sol resistivity) ρ_v and dielectric permittivity ϵ_r of the soil influence on the parameters of the lightning and grounding installations in the computer modeling of the processes occurring in them at direct lightning strikes. Therefore, their dependence on the frequency of the electromagnetic field should be considered.

The aim of the present research is measurement of electrical parameters of soils from different regions of the Republic of Bulgaria. The received data is used to improve the accuracy of sizing grounding installations of electrical power objects in the case of lightning strikes by using simulation models in Matlab. A mathematical description of the frequency dependencies of the specific volume resistivity and dielectric permittivity of the investigated soil samples is proposed.

The study involved the following stages: 1) Taking soil samples from different locations on the territory of the Republic of Bulgaria at specific depth, which is consistent with the standard grounding installation depth (0,4 m); 2) Measurement of the electrical parameters of the different soils by using a specialized laboratory equipment; 3) Creating a database of the electrical characteristics of soils on the territory of the Republic of Bulgaria, which can be used in the design of grounding installations by specialists in the field.

Laboratory measurements for determining the soil resistivity ρ_v and the dielectric permittivity ϵ_r of the studied soils at the frequency range from 1 kHz to 1MHz were done.

The received results as a database of the electrical characteristics of soils on the territory of the Republic of Bulgaria can be used in a simulation model of complex grounding systems in Matlab. Considering the measured values of the electrical parameters of the soil, a more precise dimension of the grounding and lightning installations of electrical power object could be obtained.

The specific volume resistance ρ_v of the measured soil samples decreases when the frequency of the electromagnetic field increases in most of the cases, which confirms the reliability of the results when compared with other literature sources. The relative permittivity of the soil ϵ_r varies within the range from 1,58 to 54,15 depending on the physical characteristics of the soil (humidity, density, structure, temperature).



Fig.1. Locations of taking soil samples on the territory of the Republic of Bulgaria

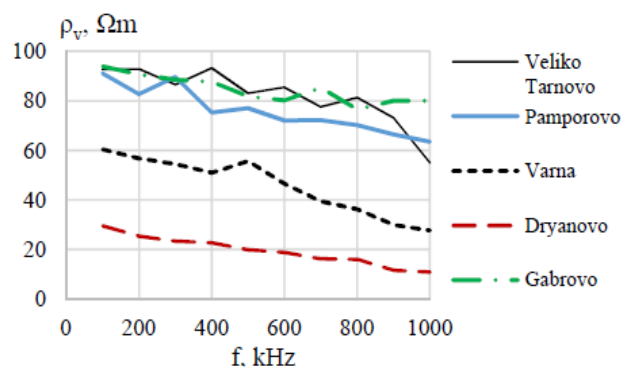


Fig.4. Results for the soil resistivity $\rho_v = \rho_v(f)$ for different locations in Bulgaria

[7] M. Yordanova, M. Vasileva, R. Dimitrova, and M. Ivanova, “A methodology for determining the maximum touch voltage in the grounding grids considering the impulse resistance”, in 2016 19th International Symposium on Electrical Apparatus and Technologies, SIELA 2016, 2016, pp. 376–379, ISBN 978-146739522-9, DOI 10.1109/SIELA.2016.7543067

The flow of the lightning current through the grounding grids of electrical substations produces impulse processes in the soil. The authors have developed a simulation model of the grounding, considering the wave processes. To expand the model, determination of the maximum possible touch voltage in these processes have to be done.

This report proposes a mathematical model, describing the dependence of the maximum touch voltage in the center of the corner cell (according to Std IEEE 80-2000 – „corner mesh“) of the grounding system, consisting of horizontal and vertical grounding rods, under the effect of impulse processes in the soil. A simulation model of the grounding installation in Matlab Simulink, which was created by the authors in previous researches, was used for this study.

The proposed methodology for determining the maximum touch voltage is original and hasn't been described in other literature sources. It is applied:

- if there are data for the potential distribution on the sides of the cells of the grounding system;
- for arbitrary construction of the grounding grid – with or without additional vertical grounding rods;
- to any point of the direct lightning stroke.

With the formulas obtained by the authors, the maximum touch voltage on the perimeter of the corner mesh is calculated. The direct lightning stroke in the first case is at the point M1, in the second – at M2 and the third one – at M3

The value of the maximum touch voltage depends on the point of direct lightning strokes. The greatest value for U_{tmax} for investigated cases is produced by lightning strokes in p.M3 – Fig.3.

The value of the U_{tmax} depends on specific volume resistances of the soil, but mostly of the value of ρ of the area near the direct lightning stroke;

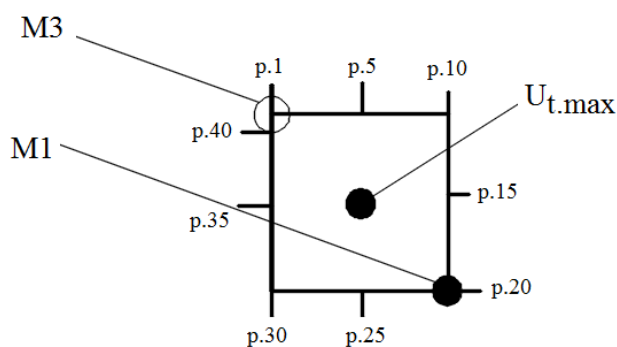


Fig.3. The points for measurement of the potentials with simulation voltmeters – 1 to 40

[8] Dimitrova, R., Vasileva, M., Yordanova, M., Ivanova, M. “Simulation model of unsymmetrically-shaped grounding grids for investigation of the touch voltages during lightning stroke,” in 2018 20th International Symposium on Electrical Apparatus and Technologies, SIELA 2018 - Proceedings, 2018, pp. 103–106, Electronic ISBN:978-1-5386-3419-6, DOI: 10.1109/SIELA.2018.8447111

Lightning activity is a natural hazard. Protection of equipment and people in electrical power systems depends on the effectiveness of the earthing (grounding) and lightning protection systems. Modeling of the earthing systems of electrical power substations is within the scope of the authors' research work. They have developed a computer model based on Matlab. The purpose of the present work is to obtain the possible contact (touch) voltages in the earthing systems caused by a lightning stroke. The model considers the specific processes that develop in the soil. The values for the maximum contact voltage have been published for an earthing grid with a regular shape of the cells and without vertical earthing rods. The paper presents a computer model for investigation of the maximum touch voltage in a rectangular - shaped grounding grid in case of a lightning stroke in different points of the grid. The influence of the impulse wave front of the lightning current has also been investigated.

The earthing system (ES) of the electrical power substations ensures the normal operation of the equipment and electrical safety of the staff. The safety is determined by the potential of the ES and possible contact (touch) and foot (step) voltages. The ES is also used as an element of the lightning protection. In the case of direct lightning strikes over the lightning protection impulse currents flow in the ES. It determines a different approach to modeling and analysis processes in ES.

The maximum value of the contact voltage can be measured in the center of corner cell of the grid. This is true only if the grid is symmetrically constructed with uniform horizontal and vertical parts. The dependence for the value of the maximum contact voltage of the earthing grid (EG) U_{tmax} has been derived by the authors in a previous research. The calculation results were obtained by using a created computer model in older studies. The aim was to receive values for the maximum contact voltage U_{tmax} for a rectangular EG with dimensions 40×70 m, the investigated corner cell and different points of a direct lightning stroke. The proposed computer model can simulate a lightning stroke at a random point. At presence of data for the potentials distribution around the perimeter – along the sides of the investigated cells of an EG can be determined the touch voltage to the center point of the cell. This is proved by the conducted studies for the rectangular EG.

The new aspect in the proposed methodology is using a simulation model of equivalent replacement circuit of arbitrary kind of EGs and the possibility to work with different electrical parameters of the soil of each point of the grid.

The obtained results for the investigated rectangular EG confirmed the conclusions, made for square-shaped EGs. The conclusions regarding the steepness of the wave front of the lightning current confirm that the shorter the waveform is, the bigger U_{tmax} is. The highest value of the mesh voltage is obtained when the lightning stroke is in p.M3.

As a summary and comparison between the results for a square and a rectangular shape, it can be claimed that the obtained results are very similar.

The value of the maximum mesh voltage at the same sizes of the investigated cell, the waveform of the lightning current and the peak value do not depend on the shape of the EG – square or rectangular.

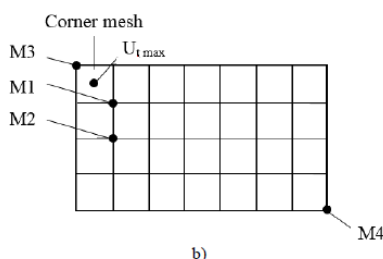


Fig. 3. a) Place of the simulation voltmeters positioning
b) The investigated cells of the rectangular EG

[9] Rangelov, Y., Georgiev, D., Georgiev, G., Kamenov, Y., Ivanova, M. “Methodological issues of soil thermal properties survey during HV cable line pre-design phase”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, Conference Proceedings, ISBN 978-172819439-4. DOI: 10.1109/BulEF51036.2020.9326062

The modern development of the power systems involves the increase of the share of underground cables. A high voltage cable sizing requires the identification of the following parameters: 1) The desired transmission capacity or, equivalently, the maximum operating current and the maximum short-circuit current at the cable connection points; 2) The extreme ambient parameters that characterize the environment thermally, i.e. ambient temperature and soil thermal resistivity with underground laying of the cable. This data form a model of the environmental factors relevant to cable sizing and are the subject of pre-design studies, whose quality largely determines the project cost and the possibility of costly serious errors as a result of sizing the cable. There is a risk both of a significant underestimation of the sizing parameters resulting in a failure due to cable overheating and of their unjustified overestimation leading to excessive project cost. The cable ampacity is strongly dependent of soil thermal resistivity.

This paper focuses on planning the pre-design studies in view of the uncertainty of the assessment of these parameters. In addition, the main sources of inaccuracies are listed and some solutions to the related problems are offered. The significance of the laboratory tests of the underground cables backfilling materials is identified. The present study provides the basis for considering the incorporation of the analysis of the correlation between thermal resistivity and the degree of backfill compaction in the laboratory tests, illustrating the impact of unreliability on sizing.

The solutions to the data uncertainty problem can follow two approaches: taking measures during the design and taking measures during the operation of the cable network.

The adequate planning of the study and the determination of the necessary design reserves require a quantitative assessment of the conductor temperature uncertainty with the input data variation. This, in turn, involves the availability of the cable temperature coefficients of sensitivity to each parameter subject to pre-design studies and the limits of uncertainty of each parameter.

The investigation of the cable route is to involve taking soil foundation samples for laboratory tests and determine its suitability as backfill. Studies related to measurements along the cable route require the application of a measurement correction to convert them to the expected extremes. Such an adjustment requires the identification of a probability model for the occurrence of extremes and should be correlated to the desired certainty, for example once every 50. The possibility of obtaining assistance from specialists studying soil characteristics for agricultural purposes should be explored.

The studies are intended to identify the backfilling suitability of the natural varieties of soil foundation detected along the route. The studies should be combined with laboratory tests in view of the disturbed structure of the soil during excavation. The results should indicate the dependence of thermal resistivity on backfill density and moisture content, as well as the possibility of soil drying caused by the heat released by the cable.

Laboratory studies are required to determine the impact of the degree of backfill compaction. Density is to be controlled during construction as well.

Avoiding discretization errors requires planning the pre-design studies as an iterative process, which is particularly relevant to the procedures related to the measurements and tests of cable burial depths. This consideration is very important when planning the time and financial resources intended for design study procedures.

[10] Georgiev, D., Georgiev, G., Rangelov, Y., Ivanova, M., Dimitrova, R., Hadzhidimov, I. "A study on the correlation between soil thermal and electrical resistivity for HV cable road pre-design purposes", in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, ISBN 978-172819439-4. DOI: 10.1109/BulEF51036.2020.9326077

One of the main problems faced during the design of underground cable lines is associated with the determination of the soil thermal resistivity for cable sizing. Studying a new cable line route involves measuring soil thermal resistivity. The main complication arises from the fact that the momentary studies conducted generally may not indicate the real operation conditions, i.e. the sizing conditions may not be relevant. The significance of the problem of the accurate determination of thermal resistivity is proved by the failures that have taken place in different parts of the world due to errors in determining this parameter. A number of cases of breakdowns caused by cable lines overheating, which although relatively rare are mainly due to the underestimated soil thermal properties, indicating the need for a more accurate evaluation of the soil thermal properties relevant in the ampacity calculation. The study of soil properties is important not only during the design cable sizing of the lines, but soil thermal resistivity monitoring is required throughout the full life cycle of the line due to the possible changes in soil parameters, which necessitate an update of the cable ampacity.

The authors' pursuit of possible approaches to solve this problem involved the analysis of publications describing the existence of a significant correlation between soil electrical and thermal resistivity. The identification of a correlation between electrical and thermal resistivity would allow for obtaining the thermal resistivity for cable sizing using the already established methods for converting the electrical resistivity measured to relevant sizing conditions. The paper offers a review of other publications that deal with the problem and presents the experimental results obtained by the authors. The objective is to verify this correlation and study its applied value.

Disturbed samples were taken from soils with different visual characteristics for the present study. Such samples correspond to the condition of the soils if they are used for natural backfilling. The destruction of the natural soil structure during excavation leads to an increase in both electrical and thermal resistivity due to the increased porosity of the material. A peculiarity is that in the case of cables, backfilling cannot be compacted with the means used in the construction of earthing installations and construction sites. Soil compaction results in a greater contact surface area between particles, and thus lower thermal resistivity. Therefore, experiments with such a type of sample are relevant and indicative of the real operating conditions of the cable line.

Every experiment involves measuring the electrical and thermal resistivity of the samples placed in suitable testing containers at approximately the same degree of compaction. The measurements were performed under the conditions of identical temperature and natural humidity of the samples. The experiments were carried out at different depths below the surface, in the same place, but at a different time.

All experiments indicate the suitability of a linear regression model of the correlation between the measured electrical resistivity and thermal resistivity. The high degree of determination provides grounds to believe that it is possible to achieve practically sufficient accuracy of determining the sizing thermal resistivity if the electrical resistivity is available. The problem requires further research since the volume of the experiments conducted so far is insufficient to justify a reliable conclusion.

The difference between the dependencies obtained in laboratory conditions and in field studies indicates the need to continue research on different soil types as different model coefficients can be expected. The difference in the standard deviations obtained in laboratory conditions and in field studies indicates that a minimum of 2-3 readings need to be taken for each point during field measurements. The good contact of measuring instruments with the soil should.

Резюмета по показател Г.7 - научни публикации в издания, които са реферирани и индексирани в световноизвестни бази данни с научна информация

[1] Panov, E., Ivanova, M., Barudov, E. “Study of the electrical characteristics of autotransformer discrete alternating voltage regulators with R-L loads,” in 2019 16th Conference on Electrical Machines, Drives and Power Systems, ELMA 2019 – Proceedings, June 2019, pp.321-325, ISBN 978-172811413-2. DOI 10.1109/ELMA.2019.8771651

Autotransformer discrete alternating voltage regulators (ADAVR) are used for limitation of the supply voltage range and thus prevent the deterioration of the electrical energy quality. In some practical applications such regulators are loaded sometimes with R-L or R-C loads depending on the type of the connected consumers. This requires conducting computer simulations of the electrical processes in ADAVR on the basis of developed mathematical models.

The paper is dedicated to the investigation of the processes in an ADAVR with R-L load. The study was conducted with the help of an automated computer program in the environment of MATLAB, allowing simulation of the processes in ADAVR at different switching ranges corresponding to different supply voltages.

The computer simulations for the ADAVR with R-L load were performed, based on the analysis of the electrical processes in the equivalent circuit of ADAVR with four thyristor switches, including the parameters of the ferromagnetic core of the autotransformer, the commutation groups, the switch-off assemblies, the parameters of the separate sections of the winding. The existing non-linearities were also considered. The specifics of the commutation of consecutively switched neighboring thyristor switches had been considered for the creation of the mathematical model as the commutation process included three separate time intervals in a previous study.

Simulations of the processes in the ADAVR with R-L load in stationary AC regime for four operating regimes, (when only one of the four semiconductor switches is closed) were performed. The alterations of the input current I_1 , the output voltage U_2 , the output current I_2 , the input real power P_{gen} , the input reactive power Q_{gen} , the output real power P_2 , the output reactive power Q_L and the efficiency η as functions of the load resistance R_L were obtained. The simulation results were experimentally verified with a prototype of ADAVR and a good correspondence was observed.

The efficiency of the ADAVR η varies from 99,831% to 98,256%, which shows a very good performance of the explored prototype.

Regarding the quality of electrical power at the regulator’s output, the change of the output voltage U_2 with the alteration of the load resistance R_L fully meets the requirements of the Bulgarian standard BDS EN50160, when the input voltage is not less than $E = 170V$.

Regarding the consumed reactive power Q_{gen} at the input of the regulator, it is obvious, that when the input voltage E is less than 180,1V and the load resistance R_L is less than 5,5 Ω , the input reactive power becomes a factor, which must be taken seriously into account.

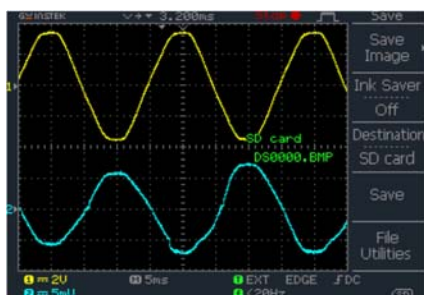


Fig. 10a. Oscillogram of the input current $i_1(t)$ at $R_L=61,8\Omega$, $L=2,1712H$, $E=160V$.

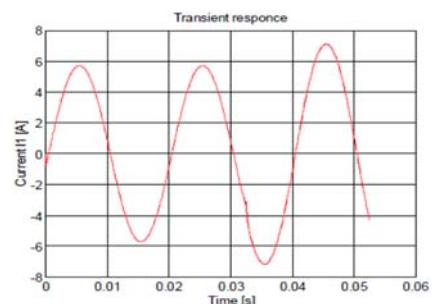


Fig. 10b. Simulation results for the input current $i_1(t)$ at $R_L=61,8\Omega$, $L=2,1712H$, $E=160V$.

[2] Ivanova, M., Panov, E., Barudov, E. “Exploration of the efficiency of autotransformer discrete alternating voltage regulators”, in 2020 IEEE International Conference Automatics and Informatics (ICAI), 1-3 Oct. 2020, Varna, Bulgaria, Electronic ISBN:978-1-7281-9308-3. DOI: 10.1109/ICAI50593.2020.9311348,

In recent years, energy efficiency issues have become increasingly popular. This is due to the increase of both the electricity consumption and the price of the basic energy sources. One of the approaches for satisfaction of the increased requirements for the electrical power quality is related to the regulation of the amplitude of the input voltage, which changes over time. An effective method for limiting the supply voltage range can be realized by using autotransformer alternating voltage regulators (ADAVR). The paper is dedicated to the research on the loading of such regulators at different ranges of commutation (different input voltages) and the change of the efficiency coefficient.

The main contribution is that an analysis of an ADAVR with a similar structure is made in terms of efficiency when working with active load.

The simulation model of the studied ADAVR allows the exploration of the random commutations over time of consecutively switched neighboring semiconductor commutating elements (SCE). The use of thyristor switches leads to a specific type of a commutation process, which includes three separate intervals.

In the first interval ADAVR operates in stationary AC regime and it is described by loop equations in phasor form. Here, only one switch in ADAVR is closed. During the second interval, the first transient process in ADAVR is observed while two of the switches are closed. The analysis is made by the state variables method in time domain, where some of the state variables are loop currents, and the rest of them are voltages across the switch-off capacitors. During the third interval, the second transient process is observed and there only a single switch is closed. The analysis is done by the state variables method in the time domain. The number of state variables is already less than in the previous interval.

A computer program AVTO was created for simulating the processes in ADAVR with four SCE in the environment of MATLAB in view of its ability for mathematical calculations in matrix form and its capability to visualize the obtained numerical results in a graphical form. The computer program AVTO includes an input block for introducing the parameters of the computational process and the explored ADAVR. In this block the durations of the first and the third interval of the commutation process, the size of the calculation step, the effective value of the supply voltage and the parameters of the windings, the ferromagnetic core, the commutating elements, the switch-off assemblies and the load are set. The program calculates and visualizes the accompanying parameters of the commutation process.

The efficiency coefficient η by theory depends on the parameters of the regulator's elements, and they are non-linear functions of the supply voltage E , the input current I_1 , the current in the transverse branch I_0 of the regulator and the load current I_2 . For the ADAVR of the explored type the efficiency coefficient η varies from 98.3 % to 99.83 %, which is an indicator for high quality of the studied ADAVR and makes it very suitable for mass use in practice due to its good performance.

Having in mind the characteristics of the output electrical power of the regulator and the behavior of the output voltage U_2 with the change of the output current I_2 it can be concluded that the explored ADAVR fully covers the requirements of the Bulgarian standard BDS EN 50160:2010.

It is seen from the simulation results, that if the supply voltage E is smaller than 180.1 V, and the output current I_2 is higher than 40 A, the consumed reactive power Q_{gen} becomes a factor, which cannot be neglected.

[3] Barudov, E. Ivanova, M. “Study of electromagnetic fields in buildings in the vicinity of a marine radar installation”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BuEF), 9-12 Sept. 2020, DOI: 10.1109/BuEF51036.2020.9326012

Radio frequency fields have many applications in modern communications. The introduction of new unmanned aerial vehicles and adaptive navigation systems in all types of transport necessitates a sharp increase in the number of radar installations of different frequency and intensity used. Radars generate electromagnetic fields (EMFs), which are called radio frequency fields. These fields with frequency 300MHz ÷ 15GHz are known to interact differently with the human body. Scanner antennas of marine radars are dangerous because they emit high frequency radio pulses that can be harmful, especially to the eyes.

The power emitted by radar systems varies from a few milliwatts (for traffic radars) to hundreds of kilowatts (for space radars). Human exposure to EMF with radio frequencies generated by radar systems is considerably limited by some factors. One of them is that radar systems operate in pulse mode, which means that the average emitted power is much lower than the peak pulse power.

In general, the occurrence of a biological effect depends on many factors that characterize the process of irradiation with non-ionizing radiation: a) specifics of the radiation source; b) antenna specifics; c) signal propagation; d) specific of the object of irradiation.

The present work is aimed at studying electromagnetic fields in buildings in the vicinity of a radar installation (marine radio-location installation type Don (JA1.150.000) with a slotted waveguide antenna, with operating frequency 9 GHz and output power 41kW). The parameters of the electromagnetic field were measured in the building below the radar installation and the risk for the workers in the building was assessed.

The parameters of the EMF in the building when the radar installation is turned on and off have been studied. From the conducted studies of the generated EMF during the operation of a radio-location system type DON can be concluded that the measured parameters of the EMF on the territory of the studied building are under the exposure limit values.

The received values of SAR (specific absorption rate) exceed the occupational exposure limits for the whole-body average SAR but are lower than the values for localized SAR for body parts. The obtained values of SAR are higher than the average SAR levels for general public exposure of the whole body at all measurement points. In the immediate vicinity of the magnetron (up to 0.5 m), the specific absorption ratio also exceeds the localized SAR level for general public exposure of the limbs. The measured values of the electric intensity E and the power density at operating magnetron are lower than the ALs for exposure to electric and magnetic fields.

The obtained results suggest application of protective measures to limit the influence of EMF at a distance of up to 1 m from the magnetron on the people working in this area. Possible protective measures have been proposed in the paper.

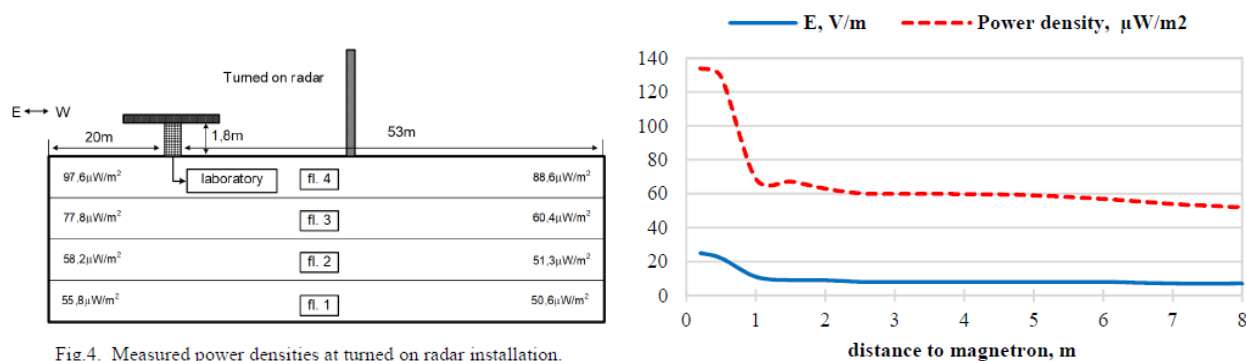


Fig. 4. Measured power densities at turned on radar installation.

[4] Panov, E., Barudov, E., Dimitrov, D., Ivanova, M. “Protection regimes and electrical quantities in autotransformer alternating voltage regulators”, in 2020 21st International Symposium on Electrical Apparatus and Technologies, SIELA 2020 – Proceedings, June 2020, DOI: 10.1109/SIELA49118.2020.9167144, ISBN: 978-172814346-0

Nowadays, voltage regulation is necessary for protecting industrial and household consumers against voltage fluctuations in the power supply, because they can cause severe damages to the equipment. Most electrical devices can stand supply voltage up to a certain limit.

The main objective of the present research is to study the processes in an autotransformer discrete alternating voltage regulator (ADAVR) at emergency regimes, which are protected against overcurrents and overvoltages. The specific processes have been explored by using a Matlab simulation model, previously developed by the authors. The novelty of the present work is the combination of the model of ADAVR with different types of protections and the analysis of the operation of the protected device. Finally, an experimental verification of the simulation results has been done.

The overcurrent protections (OCP) are implemented at the input, at the output and before each of the commutating elements of the regulator. Each commutation element (semiconductor thyristor switch) of the ADAVR is also protected by overvoltage protections (OVP). For the current case the OVP is realized by R-C groups (snubber circuit thyristor overvoltage protection). The two types of protections that are used in the model react to the rms values of the electrical quantities (currents or voltages).

A simulation model of ADAVR with overcurrent and overvoltage protections including the non-linearities of all elements of the circuit was proposed and used for determining the electrical quantities of the protection devices.

In this way the currents flowing through the input, the output and through the semiconductor commutation elements of the explored ADAVR, as well as the transient processes in the different sections of the regulator (at the different commutation levels), were obtained.

The results from the simulations can be used for more precise setting of the different devices for protection of the explored ADAVR.

At the same time the experimental results showed a very good coincidence with these from the simulations (error of the model less than 1%), which is a good verification of the validity of the obtained data.

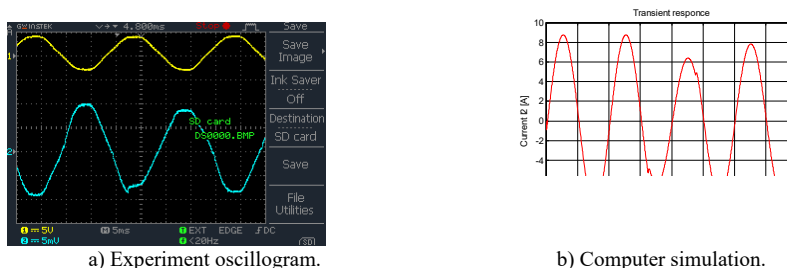


Fig.10 Output current $i_2(t)$ (OCP_{out}).

a) Current through OVP₄. b) voltage over OVP₄.

Fig. 11. Current and voltage in the snubber circuit.

[5] Panov, E., Ivanova, M., Barudov, E. “Study of the parameters of an autotransformer discrete alternating voltage regulators considered as a two-port”, in 2021 17th Conference on Electrical Machines, Drives and Power Systems, ELMA 2021 – Proceedings, pp.377-380, ISBN 978-166543582-6. DOI 10.1109/ELMA52514.2021.9503020

The study is devoted to a new type of analysis of an autotransformer discrete alternating voltage (ADAVR) regulator as a two-port. The examined regulator consists of four semiconductor commutators (thyristor switches), corresponding to the different levels of the input supply voltage.

The aim is to determine its hybrid parameters (H-parameters) along with the specific hybrid systems of equations (H-equations) as the regulator is considered as a two-port. This type of parameters and equations are important because the considered devices are objects of power electronics and it is necessary to know or to be able to quickly determine their parameters such as current and voltage gains and others. Since the H-parameters do not provide the complete set of parameters from a practical point of view, it is convenient to find the G-parameters as well.

The ADAVR considered as a two-port with resistive load at forward transmission, was examined. The values of the phasors of the input and the output voltages and currents for 4 intervals of the supply voltage, which correspond to different closed commutators ($S_1 \div S_4$) have been obtained by simulations in MATLAB. These results were verified experimentally by the help of series of vector measurements and a good correspondence smaller than 1,2% was admitted.

The obtained H- and G - parameters were used for fast calculation of the phasors of the quantities I_1 , U_2 and I_2 at resistance $R_L = 35,552\Omega$; 11Ω ; $5,5\Omega$; $3,4921\Omega$ in the range of change of the input voltage in the range $E = U_1 = 220V \div 160V$ and in particular at $E = 220V$; $200V$; $180V$; $160V$. The obtained experimental results coincide with the results of the performed computer simulations with accuracy 1,2%.

As a results of the study, the following conclusions can be drawn:

- At input voltage in the interval $E = U_1 = 220 \div 200,1V$, the studied regulator can be considered as a symmetric two-port, and for $E = U_1 = 200V \div 150V$, it should be considered as a non-symmetrical one.
- For the explored type of ADAVR the principle of reciprocity is valid, i.e. $H_{12} \approx H_{21}$ and $G_{12} \approx G_{21}$, nevertheless the ADAVR is a non-linear device.
- The obtained H- and G - systems of equations allow fast and precise analysis of the parameters of the ADAVR, the current and voltage gains. This facilitates the calculation procedures connected with the design and the practical application of ADAVR.

From engineering point of view, important basic parameters of such an electronic device are the current and voltage forward gains during operation under load. Determining the H- and G-coefficients makes it possible to determine these two coefficients.

[6] Panov, E. Barudov, E., Ivanova, M. “Exploration of the electric processes in discrete alternating step-voltage regulators,” in 2018 20th International Symposium on Electrical Apparatus and Technologies, SIELA 2018 - Proceedings, 2018, pp. 314–317, ISBN 978-153863419-6. DOI 10.1109/SIELA.2018.8447122

An important requirement for the electric power quality is the range of alteration of the input supply voltage amplitude. One of the ways for meeting this requirement is by implementation of autotransformer discrete alternating voltage regulators (ADAVR) with semiconductor commutation elements (SCE). The design and the construction of such regulators require modern approaches for computer analysis and simulation of the complex processes occurring in these devices. The major problem is the development of an adequate model and algorithms for analysis, which would enable the achievement of accurate solutions and true simulations of the ADAVR responses in a variety of operative modes and in emergent situations. The final goal of the whole research is to develop and to implement a procedure for virtual and practical design of ADAVR.

The paper presents a review on the problems of the analysis of autotransformer discrete alternating voltage regulators. The analysis has been made basically by the state variables approach in the time domain, where the non-linearity of the regulator components has been considered. A special algorithm has been developed for part-by-part solving of the obtained sparse matrix equations with cell structure. Experimental verification with a prototype has been performed, which showed a good correspondence with the simulation results.

A mathematical model for description of the commutation processes in ADAVR and a detailed algorithm for solving the system of equations, describing the electrical equilibrium in the voltage regulator, are proposed.

A computer program AVTO has been developed for simulation of the complex processes occurring in ADAVR during the commutation processes, which enables a complete analysis of the explored devices.

The conducted analytical and experimental research with different phases of commutation and types of the load show a very good correspondence of the obtained results, which demonstrates the adequacy of the model and gives the opportunity of virtual design of ADAVR.

[7] Ivanova, M., Dimitrova, R., Filipov, A. “Analysis of power outages and human errors in the operation of equipment in power grids”, in 2020 IEEE 12th Electrical Engineering Faculty Conference (BulEF), 9-12 Sept. 2020, Conference Proceedings, ISBN 978-172819439-4, DOI: 10.1109/BulEF51036.2020.9326058

The continuous development of the power systems by implementing new technologies for management and connection of new sources of electricity requires improvement of the power supply security and determines the need for detailed analysis of the causes of power outages and measures to improve the security of power grids, including their cyber security.

Human activities worldwide depend to a large extent on the power supply. Power outages have a significant impact on companies operating in the affected areas. Companies (customers) that have manual or automatic redundancy of power supply may also lose production hours while switching to it, which leads to losses in production and revenue due to non-compliance with deadlines, unproduced and unsold products, etc. Power outages for household customers can lead to damages of the household equipment and therefore to financial losses for both consumers and electricity companies, such as unsold electricity and the payment of compensations. Therefore, it is extremely important to consider and analyze power outages and cascading events in the power systems.

The present work is dedicated to analysis of the causes of power outages in the medium and high voltage power grids on the territory of the Republic of Bulgaria. The main types and places of occurring power outages in power lines, substations and power transformers have been analyzed. The reasons for disconnections in substations and power lines, as well as possible damages of power transformers and equipment have been analyzed. The listed causes of outages in the power supply do not exhaust all possibilities, but can be used for more generalized classifications of the main types of damages.

Indicators for assessment of the power outages related to power lines and substations are presented. Measures to improve the technical condition of high voltage power lines, substations and medium voltage switchgear are proposed.

The power outages due to human errors of the service personnel in the power grids have been considered and measures to prevent such accidents.

[8] Ivanova, M., Yordanova, M., Dimitrova, R. “Evaluation of the step voltages for grounding grids at lightning strikes”, in 2020 21st International Symposium on Electrical Apparatus and Technologies, SIELA 2020 – Proceedings, June 2020, DOI: 10.1109/SIELA49118.2020.9167157, ISBN: 978-172814346-0

The design of protective installations (grounding installation - GI) of high voltage substations has great importance related to the technical safety of the entire facility. The values of fault currents in the substation GI (including due to lightning strikes) may reach tens of kA and the Ground Potential Rise may rise up to tens of kV independently from the grounding resistances. This can cause severe damages to the electrical equipment and human casualties. Considering the ground resistance, touch and step voltages and the possible potential spread outside a GI territory is necessary in the process of the GI design.

This paper suggests an approach for determination of the permissible step voltages' values in grounding installations under the effect of impulse lightning currents with a certain shape. The allowable body current was determined as an energy limit of 10J was accepted as the lowest determined value by researchers in the literature. Comparison of the obtained maximum step voltages and the values of defined permitted step voltages has been done by using a previously developed by the authors model for simulation the processes in grounding grids when the lightning currents flow in them.

The standards for design of GI do not define norms for allowable step voltages, so a practical method for evaluation of the risk of electrical hazards from lightning currents in grounding installations is to use allowed energy to determine those voltages. That energy is used to determine the permissible (tolerable) current through the body and after that it may be used the known dependence on the standard IEEE Std 80- 2000.

The parallel between the calculated step voltages in the different points of the grounding grid perimeter at for different points of lightning current strokes - M1, M2, M3 from the simulation model and the values of maximum step voltage, determined by the IEEE80-2000 equations demonstrates the usefulness of the model for assessing the electrical safety of GI.

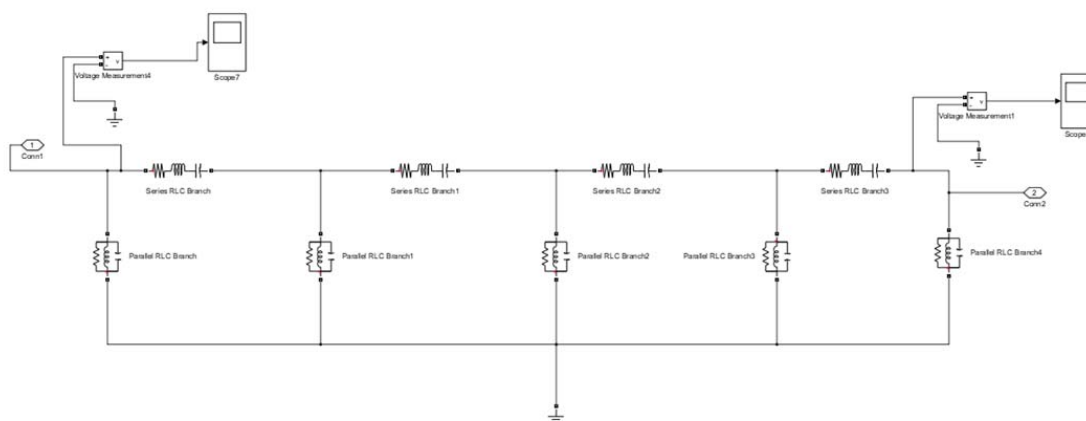


Fig.3. Simulation model in Matlab of a section of a grounding system with horizontal earthing elements.

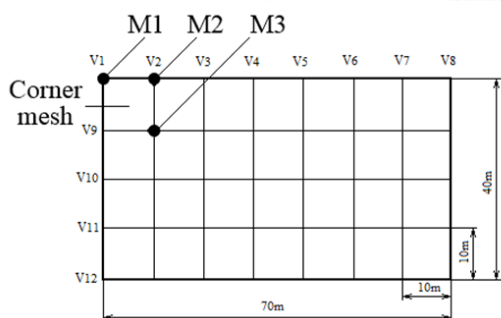


Fig. 1. The investigated rectangular-shaped grounding installation with dimensions 40 x 70 m., M1÷M3 are the points of direct lightning strike.

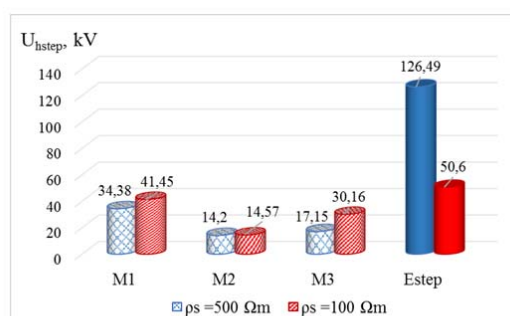


Fig.6. Comparison of the maximum step voltage in the GI depending on the point of direct lightning strike with the permissible value of E_{step} .

[9] Mehmed-Hamza, M., Filipov, A., Ivanova, M. “Research and analysis of faults in medium voltage distribution grids”, in 2021 56th International Scientific Conference on Information, Communication and Energy Systems and Technologies, ICEST 2021 – Proceedings, pp. 227-230, ISBN 978-166542887-3. DOI 10.1109/ICEST52640.2021.9483457

Medium voltage distribution grids (MVDG) in Bulgaria are with a radial topology and mostly with a voltage level of 20 kV. Emergency power outages are caused by earth faults and less frequently by phase-to-phase faults.

The paper presents data from a study of the faults and relay protections trips in a 110/20 kV substation for a period of two years. A research on the automatic trips of relay protections depending on the type of fault and the type of power lines for a year and for each month separately has been made. An analysis of the earth faults and the phase-to-phase faults both for the entire MVDG and depending on the type of medium voltage power lines was made. The monthly distribution of the automatic trips of the relay protection of the power lines was also studied. The faults analysis showed what are the prevalent types of faults both for the entire grid and for the overhead and cable lines separately. The results regarding the monthly distribution of the faults revealed on which lines and in which months are the main problems in the operation of the lines. A study on the effect of auto-reclosing on the overhead power lines was made. The successful auto-reclosings for 2018 are 87 %, and for 2019 – 85 % from the total number of auto-reclosings. The high percentage of successful auto-reclosings on OPL showed that the faults had a transient nature.

In medium voltage distribution grids, earth faults are predominant and primarily occur on overhead power lines. The trips in MVDG occur during the summer months predominantly, and the faults have a primarily transient character. The outage rate of OPL and mixed overhead and underground cable lines is greater compared to cable lines.

The electricity distribution companies operating the power grid need to perform an analysis of the relay protections trips, which would reduce the failure rate. Carrying out such an analysis for each power line and taking measures to reduce the number of trips will lead to an improvement of the power supply of the consumers and the operational safety of the facilities. The processing of the information from the relay protections would be significantly simplified if the data were collected automatically.

The main contribution of the paper is that an approach for analysis of the faults on the MV lines, which can be used by the electricity distribution companies for increasing the power supply reliability, is proposed.

TABLE I
TYPES OF POWER LINES OF THE STUDIED MVDG

Line type	Overhead power line (OPL)	Underground cable line (CL)	Mixed overhead and underground cable lines (ML)
Number of lines	7	7	4

TABLE II
DISTRIBUTION OF THE PHASE-TO-PHASE FAULTS DEPENDING ON THE LINE TYPE

Year	Overhead power lines	Cable lines	Mixed lines
2018	55.7 %	24.3 %	20 %
2019	60.9 %	29.7 %	9.4 %

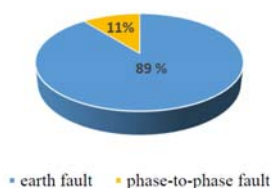


Fig. 1. Percentage distribution of the relay protections trips for the studied MVDG in 2018 depending on the fault type

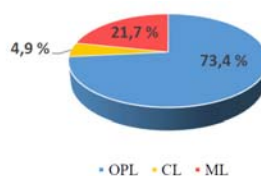


Fig. 3. Percentage distribution of the relay protections trips depending on the line type in 2018

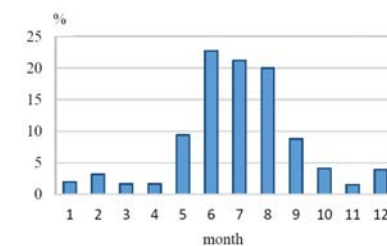


Fig. 8. Percentage distribution of the trips of all types of protections of the studied MVDG by months in 2019

Резюмета по показател Г.8 - научни публикации в нереферирани списания с научно рецензиране или в редактирани колективни тонове

[1] Dicheva, M., Barudov, E. “Expert evaluation of the quality of the electricity and the power supply”, Proceeding from the Annual university conference of the National Military University “Vasil Levski”, Veliko Tarnovo, 2009, vol.6, pp. 173-181, ISSN 954-753-035-6. (In Bulgarian)

The dynamics of changing the connected consumers and the development of the electric transmission and distribution grids have significant differences. This puts more persistently the question for the quality of the electrical energy, uninterruptedness of the electrical supply and the quality of the commercial services. The variety of the processes makes difficult the formation of correct quantitative assessments.

The aim of the present work is to develop a system for expert assessment of the quality of electricity and power supply, based on the existing regulatory framework, overcoming these weaknesses and introducing a sufficient number of discrete levels of assessment. An expert quality assessment system includes: statistical evaluation of electricity quality indicators (EQI); methodology for forming an expert assessment of the quality of electricity and electricity supply.

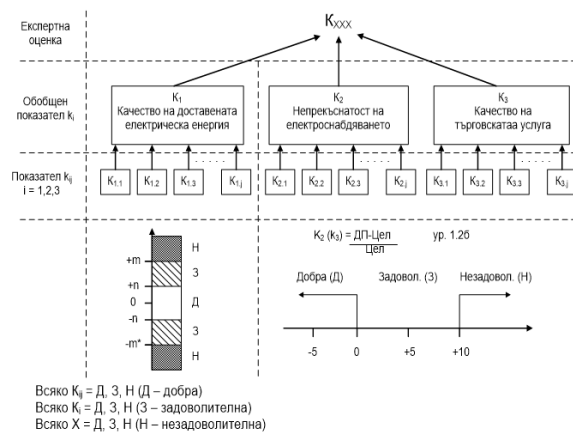
The main reasons for changing the EQI are the constant changes in the parameters of the grid, the power and the load, which are random. Therefore, the values of EQI are random variables, so their measurement and information presentation should be based on probabilistic statistical methods. This determines the need for the standards established for EQI to consider that their values correspond to 95% duration over time (for example every day). A complete description of the random variables is presented by the law of their distribution, which determines the probability of obtaining any value of the indicators.

The analysis of the statistical data from the operation shows that the most accurate law for distribution of the magnitude of the EQI in the power grid is the normal distribution for day-and-night, weekly and longer period of change. Particularly typical in this case is the indicator "voltage deviation" – δU .

Due to the random nature of the magnitudes of EQI, their information presentation, evaluation and measurement are performed by using probable - statistical methods: mathematical expectation of the random variable and the scattering around it.

The proposed system for expert assessment of the quality of electricity and power supply uses the existing regulatory framework. It replaces the not so well-defined coefficient of relative significance (weight) with a reserve percentage when meeting the requirements. A sufficient number of levels of discretization of the assessment is provided - 27. The strengths and weaknesses in terms of quality of electricity supplied and quality of service are easily visible.

The system can be used by a wide range of specialists, including those involved in the operation and development of power grids. The system is flexible in terms of the number of indicators covered, types of grids (urban, rural ...) and allows development.



Фиг. 2 Структурата на методика за формиране на експертна оценка за качеството на електрическата енергия и електрооборудването.

[2] Barudov, S., Dicheva, M. "E-learning in the Electrical Engineering Faculty at the Technical University of Varna. Practice and problems.", in 3rd national conference with international participation in e-learning in higher education, Proceedings, vol. 1, Dimitar A. Tsenov Academy of economics, Svishtov, 2009, pp. 297-304, ISSN: 978-954-23-0427-2. (In Bulgarian)

A representative survey conducted within several years at the Technical University - Varna regarding the number of working students in the Bachelor's degree shows that in different years between 20% and 30% of students work. The sample covers over 10% of the students, evenly distributed by courses and specialties. The percentage of working students in the Master's degree is significantly higher. This implies looking for flexible training opportunities for working students. For students in the field of Technical Sciences, the problem of acquiring knowledge and practical skills in these conditions can be solved using the possibilities of e-learning.

In the Faculty of Electrical Engineering of the Technical University - Varna the electronic form of education in parallel with the classical forms of full-time and part-time education began to be used in the academic year 2005/2006, covering the majors "KST", "KTT", "AIUT", "Electronics", "EEEE" and "Electrical Engineering" for educational qualification degrees "Professional Bachelor" and "Bachelor", as well as for the needs of English language education. The disciplines "Materials and components in electronics", "Materials science", "Electrical materials" for first-year students are covered, and currently it is used for training second- and third-year students in other disciplines. The emphasis is on weekly controlled independent work, considering that this type of work presupposes the acquisition of more in-depth knowledge.

The platform used - LCMS (Learning Content Management System) is based on the software platform for distance learning at the University of Munich (Open source), which is improved early. Therefore, this choice of platform implies that significant costs for the annual development of the software platform will be eliminated.

With the use of electronic forms of education, the learning environment becomes visible, which raises the question of the nature of the materials used, to the extent that they, in addition to the lecturer, represent the university. As this issue is not regulated, one possible approach is to provide the above teaching aids and receive feedback and recommendations. In the present case, the cited aids were provided at 24 universities in 12 countries.

The experience from the application of this form of education during the last 3 academic years has shown improvement of the academic and administrative service of the students, documentation of the results of their weekly work, which, if necessary, allows timely assistance in mastering the study material. The accumulated results show that over 80% of the students (over 400 per academic year) adopt the form of e-learning and are actively involved. In general, the success with the parallel use of traditional forms and e-learning is higher.

The problems, considering the platform usage were summarized and recommendations for its usage in the educational process were given:

- There is no normative regulation for this form of education both in terms of the workload of tutors and in terms of the rights and obligations of students.
- Problems with the Internet make it difficult to conduct some exam procedures.
- Presentations can be reduced and combined at the expense of curriculum development.
- There is no regulation for the use of the results from the implementation of the weekly schedule.
- Possibility to introduce optional disciplines and courses recommended by users without increasing the hours.

[3] Barudov, S., Ivanova, M. “Discharge element with transverse high-frequency excitation”, in XLVI Int. scientific conference on information, communication and energy systems and technologies ICEST 2011, 2011, Nis, vol.3, p.959-962, ISBN: 978-86-6125-033-0.

The usage of high-frequency transverse discharge in technologies for treatment of liquid fluids presents practical interest because: the discharge is characterized by higher stability; reactive elements can be used as a passive load and efficiency coefficient increases; there is symmetric energy dissipation; electrodes with dielectric coating can be used, which solves the problems with their sputtering.

The work is devoted to study of the possibilities for application of single circuit generators with automatic pre-voltage and inductive-capacitive matching converter for excitation of a transverse discharge and control of its parameters according to the technological application.

The effectiveness of the discharge medium excitation highly depends from the ratio between the frequency of the external field and the frequency of the interaction between the electrons and the atoms and more precisely if the electrons energy succeeds to follow the change of the external field during the oscillation period.

Two-ports with reactive elements are connected between the load (the discharge element) and the generator. They ensure converting of the generator output voltage into constant current through the load according to its specific properties and transformation of the active part of the load resistance in resistance of the circuit. The dependency between the anode voltage U_a and the converter input voltage U_L with a load (the discharge element) is necessary to be found for calculation of the relationship.

The aim of the present work is study of the possibilities for ensuring of starting and operating modes of the transverse discharge, its control and choice of a converter as a matching section for transforming the output voltage of the resonant circuit into current of the discharge element.

It is proposed a variant of a lamp high-frequency generator with a matching section – L-shaped inductive-capacitive converter, which gives the possibility at generated frequency of 2MHz for ensuring starting and operating mode for excitation of a transverse discharge. The generator provides possibility for fine adjustment of the discharge current in the range of 25÷100 mA at maximum output power 350 W.

The studies of the discharge current stability as a function of the change of the generator parameters and those of the discharge plasma reveal appropriate choice for the matching section.

[4] Barudov, S., Dimitrova, R., Ivanova, M. “Single-circuit and double-circuit regulating apparatus for gas discharge element”, in XLVII Int. scientific conference on information, communication and energy systems and technologies ICEST 2011, 2011, Nis, vol.3, p.956-958, ISBN: 978-86-6125-033-0.

The purposeful usage of electrical discharge is related to its development in a specific, artificially created medium – a discharge element. Due to the specifics of the discharge elements, they are connected as a load to the power supply grid by regulating apparatuses. The work is dedicated to a comparative study between single-circuit (SCRA) and double-circuit regulating apparatuses (DCRA) for control of a direct current discharge with respect to the stability of the discharge current (current stabilization coefficient of the load) and the power parameters of the regulating apparatuses (dissipated power by the regulating element and efficiency coefficient).

The SCRA consists of an uncontrollable rectifier (a dc voltage source with magnitude U_{Dmax}^* – Fig.1), which supplies a regulating element (RE) connected in series with a compensation stabilizer (CS) and a discharge element (DE). $U = U_{Dmax}^* - U'_D$ provides stabilization of the discharge current at a change of the amplitude of the input supply voltage.

The DCRA consists of a controllable rectifier which controls the voltage over the regulating element of the compensation stabilizer. Most often, in operating mode the controllable rectifier realizes the law $U_{RE}=const$ or switches on a regulator of the input supply voltage, which limits the fluctuation of the amplitude of the input supply voltage.

The DCRA for discharge elements in comparison to the SCRA provides increased stabilization coefficient of the discharge current only with respect to the change of the input supply voltage. This coefficient quantitatively depends on the character of the feedback of the controllable rectifier.

The DCRA can realize one of the following laws: $\Delta U_{S0} = const$ (DC1RA) or $\Delta U_{RE} = const$ (DC2RA). The choice of the law is a matter of compromise. DC1RA ensures a higher stabilization coefficient of the discharge current related to the change of the input supply voltage but a lower efficiency coefficient and higher dissipated power of the regulating element and vice versa.

The realization of the second control circuit with a controllable rectifier or a step AC regulator also is a question of compromise. The controllable rectifier gives a better efficiency coefficient and lower dissipated power of the regulating element, yet worse power factor and higher level of electromagnetic interference and vice versa.

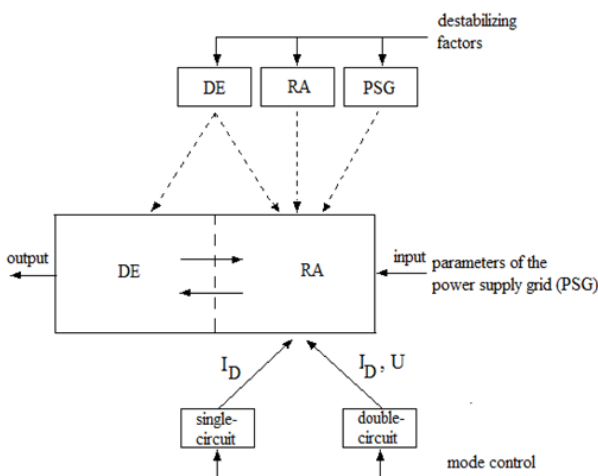


Fig.2. System “regulating apparatus (RA) - discharge element (DE)” – input/output parameters, destabilizing factors, control modes

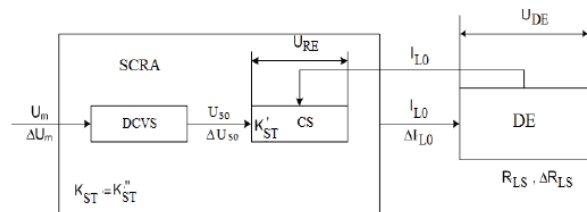


Fig.3 Block diagram of SCRA

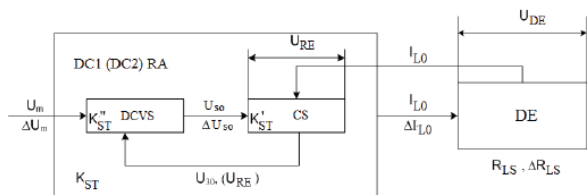


Fig.4 Block diagram of DCRA

[5] Barudov, S., Ivanova, M. Dimitrova, R. “Study of the commutation capabilities of a controllable air discharger in circuit of high-voltage pulse discharge”, Annual proceedings of the Technical University of Varna, 2011, Bulgaria, vol. I, p.15-20, ISSN: 1311-896X.

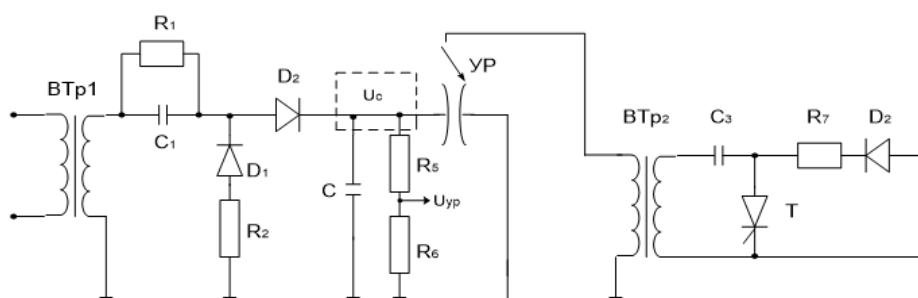
Generators for formation of a high voltage discharge pulse are based on a charging circuit for capacitive energy accumulation and a discharging circuit with a switching element, most often – a controllable air discharger. In the paper are studied the commutation capabilities of a three-electrode controllable air discharger with two gas discharge gaps different in space, which occur consecutively in time and refer to the appearance of the discharge and subsequent formation of a high voltage discharge pulse.

The circuit including the charged capacitor battery (CB) - C (Fig. 1), the connecting wires and the controllable air discharger (CD), can be considered as an RLC circuit for which: $R = R(t)$ - the nonlinear resistance of the gas discharge gap in the CD; L - inductance of the connecting conductors and parasitic inductivities of connected capacitors from CB connected in series and/or parallel; C - capacity of CB. The studied CD is a three-electrode one, with two separate discharge circuits and two spatially different gas discharge channels, developing sequentially over time. One of the channels ensures the occurrence of the discharge, based on a package of high-voltage high-frequency pulses, and the second one forms a high-voltage pulse discharge, based on the energy accumulated in the capacitor battery.

The aim of the present work is, for a specific CD, to be experimentally studied: discharge current - $i = i(t)$; voltage over the CD - $u_{cd} = u_{cd}(t)$; the voltage to which CB remains charged - Fig. 1 after disintegration of the gas discharge channel in the CD (suspending of the discharge process); energy given off in the gas discharge gap; the resistance $R = R(t)$ of the gas discharge gap of the CD, at parameters capacity of CB and voltage to which it is charged before the formation of the discharge pulse - U_C .

For the specific CD and discharge circuits the character of the formed pulse is determined - periodically attenuating high-voltage pulse with a frequency of $36 \div 71$ kHz and a duration of about $100 \mu s$ for a capacitor battery with a capacitance of $0.5 \div 2 \mu F$. The time delay of the formed periodically attenuating pulse is determined, after the supply of the high-voltage high-frequency pulses - $160 \mu s$. The maximum discharge current is determined, at parameters capacity of CB $C = 0,5 \div 2 \mu F$ and voltage to which it is charged - $U_C = 9,5 \div 11,5$ kV, varying in the range from 0,6 to 2, 8 kA. 4. At the same above-mentioned parameters, the voltage on the CD is determined, at which the discharge is stopped - $2.5 \div 5.5$ kV. The energy of the formed high-voltage discharge pulse is also determined - $14 \div 124$ J.

The obtained dependences and the indicated parameters can be used for sizing of discharge circuits with a key element - the investigated three electrode controllable air discharger operating at atmospheric pressure, and the research methodology can be applied to other design parameters of controllable arresters.



Фиг. 1 Принципна схема на зарядна и разрядна вериги

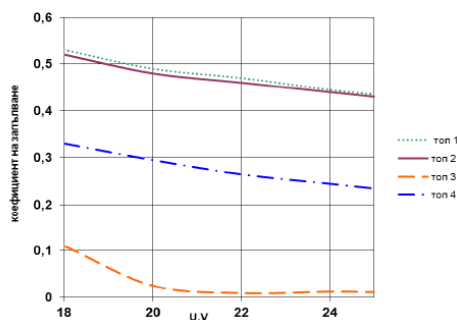
[6] Dimitrov, D., Dimitrova, R., Ivanova, M., Vassileva, M. “Analysis and comparative evaluation of energy effective drivers for LED with autonomous power supply”, in 3rd International congress “50 years Technical university of Varna”, 2012, Varna, vol. III, p.110-115, ISBN 978-954-20-0552-0. (In Bulgarian)

Autonomous power supply is the case of power supply from a battery charged by a PV module. The increasing application of LEDs is determined by their high efficiency: getting high light output; increasing the service life; simplified automation of their mode of operation. To achieve this efficiency, the scheme of the LED drivers and their control mode is essential. The characteristics of the LED drivers are determined by the way the LEDs are connected (in line or matrix). Therefore, a variant study of topologies is needed, which determines smaller losses in the driver elements.

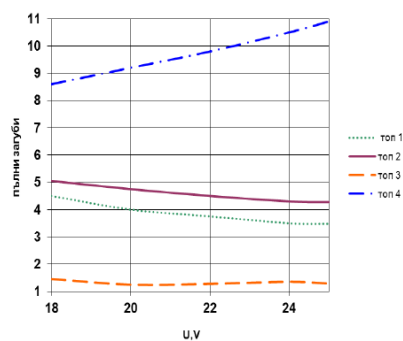
For different topologies of drivers for LEDs and connection configurations of the LED matrix is performed comparative evaluation of the scheme parameters, losses, energy indicators and their main characteristics depending on the supply voltage. Based on the conducted analysis are defined energy effective topologies of drivers and ways of LEDs connection in a matrix.

Modelling with different programs is accepted in the research. The building blocks of the drivers are from INTRON, Infineon, WENSON, IFcore, CREE, P.LEO, Power Integrations, etc., whose elements are in the database for the used version for modeling - SMPS design software. The result of the research refers to the choice of a high-efficiency driver solution, respectively light output and the most favorable heat load of the elements. A study of five types of driver circuits was performed - RCC – Flyback (1), RCC - Flyback (IC replaces transistor) (2), Boost (3), Resonant (4), and a topology special driver (5) for a certain type of LED, as their functional performance and efficiency at different way of connecting LED are evaluated. They are provided with the required current stability when the supply voltage and load change within certain limits.

The performed study showed that when regulating the LED current, the pulse filling coefficient changes in the range of 8%, acquiring smaller values in topologies 3 and 4. The induction in the magnetic circuit of the transformer is almost independent of supply voltage, as for topology 4 it is relatively low - $B = 0,1$ T. The total efficiency is relatively high at topologies 1 and 2 and maintains high values depending on the supply voltage. Based on the comparative assessment, the following has been determined: driver topology with the highest efficiency; number of strings and number of LEDs in them, where the losses of the elements are minimal; driver topology and ways of connecting LEDs in a matrix, in which the distribution of losses in the individual elements is more uniform; dependences of characteristic values - pulse filling coefficient, induction in the magnetic circuit of the output transformer, the losses in the elements and the efficiency of the driver when the supply voltage changes.



Фиг. 6а. Зависимост на коефициента на запълване на импулса от захранващото напрежение



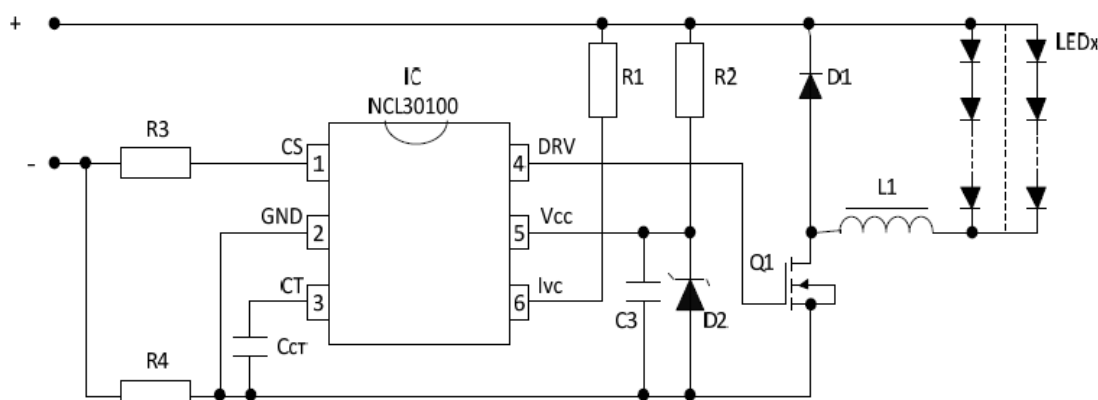
Фиг. 6в. Зависимост на пълните загуби от захранващото напрежение

[7] Dimitrov, D., Dimitrova, R., Ivanova, M., Vassileva, M. “Study of some influences of the internal parameters of specialized integrated circuits for LEDs”, in 3rd International congress “50 years Technical university of Varna”, 2012, Varna, vol. III, p.116-121, ISBN 978-954-20-0552-0. (In Bulgarian)

The growing use of LEDs is leading several semiconductor device manufacturers to create specialized integrated circuits (ICs) designed for LEDs. Their specialization is that in their work they meet the requirements of the LED as a load: current stability, limiting its pulsations, modular design of LED, a small number of externally connected elements and more. These are ICs from the series NCLxx ..., NCPxx..., etc., designed for different topologies of drivers, for drivers with transformerless output, for drivers with $I_{LED} = 0.35 \div 1.5$ A, with power $1 \div 50$ W. NCL 30100 has good quality indicators: simplified setup and wide field of application of LED in matrix, which is why it is the subject of research.

The aim of the research is to analyze the functional capabilities of an IC specialized for LED, to present its specificity from the internal parameters, as well as to present their influences on the characteristic values of LED drivers. In the research it is appropriate to use the method of the average values and substitution schemes of pulse converters, as well as the state variables method during the intervals of operating mode and pause. In the case of variant solutions for connecting LEDs in a matrix, as well as varying the powers of LEDs, the research uses specialized computer modeling "ON Semiconductor - EEES" - (Enabling Energy Efficient Solutions). The solution is interactive with components from the software library (or similar), considers the nonlinearity of the V-A characteristic of the LED and presents time diagrams of the main electrical quantities of the driver and the electrical load of the participating semiconductor elements in the driver.

Confirmatory results have been obtained for the operability of a series converter, uninsulated, with multi-variant connection of LEDs in a matrix. The implementation variant (3 strings x 2 LEDs in a string) with the highest efficiency - 89%, providing stability and allowable current ripple, was proven. The electrical values of the LED and the driver at different loads are determined, taking into account the own parameters of a specialized IC.



Фиг. 1. Схема на свързване на NCL30100 за захранване на LED

[8] Ivanova, M., Barudov, S. “Comparative analysis and modelling of a high voltage periodically attenuating discharge in liquid in a circuit with two discharge gaps”, Marine scientific forum, 16-17 may, 2013, Nikola Vaptsarov Naval Academy, pp.110-117, ISSN 1310-9278. (In Bulgarian)

The aim of the present work is to experimentally determine the resistance change of two types of high voltage switches – a trigatron and a thyatron at parameters the capacitance of the capacitor battery C and the voltage U_c , to which it is charged of a system for generation of high voltage discharges in liquid, based on capacitive energy storage. A mathematical model of the same dependencies $R_{hvs}(t)$ of the two switches and the usage coefficient of the capacitor battery are determined.

Four experimental studies for the discharge current I_d were performed: 1) capacitor battery is discharged only through a controllable switch trigatron; 2) the capacitor battery is discharged through a controllable switch trigatron and a discharge gap in liquid; 3) capacitor battery is discharged only through a controllable thyatron switch; 4) capacitor battery is discharged through a controllable switch thyatron and discharge gap in liquid. The alteration of the active resistance and the inductance in time of the discharge circuit were determined for all cases. The obtained results are relevant for a trigatron with certain geometric dimensions, a thyatron TGI1-1000 and a uniform field created by hemispheres with a distance between them of 5 mm in the aqueous medium.

Assuming that the resistances of the controllable high-voltage switches and of the discharge gap in the fluid during a half-period of a periodically attenuating oscillation do not change, it can be generalized: 1) Approximately 80% of the energy stored in the capacitor bank is transferred to the discharge in the liquid within the first period of the attenuating periodic oscillation; 2) The specified percentage slightly depends on the type of high-voltage switch, but is higher with a controllable high-voltage switch trigatron; 3) The specified percentage slightly increases with increasing capacity of the capacitor bank and the voltage to which it is charged; 4) When using a controllable high-voltage switch - trigatron, the frequency of the periodically attenuating oscillation changes in the range $72 \div 36$ kHz, and for a thyatron - from 39,4 to 19,7 kHz when the capacity of the capacitor battery changes from $0,5 \div 2$ μ F.

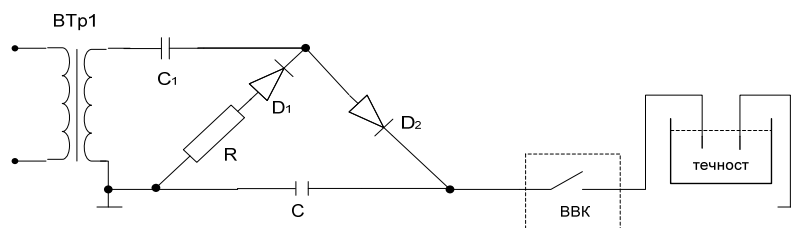


Fig.1 Principal scheme for formation of a high-voltage discharge in liquid



a/ trigatron



b/thyatron

Fig. 5 Controllable dischargers

[9] Ivanova, M. “Study of the energy characteristics and the temperature influence on the liquid medium resistance during the formation of a high voltage discharge”, in L international scientific conference on information, communication and energy systems and technologies – ICEST, 2015, Sofia, p.292-295, ISBN 978-619-167-182-3.

Under the formation of high voltage discharges in liquid medium many physical and chemical processes occur, which depend on many different factors (characteristic of the electric field, composition of the liquid medium, external parameters such as temperature, pressure, etc.). The resistance of the formed plasma channel at a high voltage discharge in liquid depends on the alteration of the free current carriers' concentration in it. Some of the factors which impact on the process are: recombination of current carriers; drift movement of current carriers; scattering of current carriers outside the plasma channel at the expense of a thermal diffusion and appearance of a hydraulic wave. The processes develop with high dynamics and different time constants, which most commonly depend on the structure of the medium, external factors (temperature, parameters of the electric field, elements of the discharge circuit and spatial geometry of plasma channel. Their mutual influence is difficult to be covered analytically and this requires conducting of parametric experimental studies.

Considering the dynamics of these processes, the purpose of the present work is experimental study and analysis of the influence of the temperature and the energy characteristics on the liquid medium resistance change at the formation of a high-voltage discharge pulse.

The charging circuit of the studied system for generation of high voltage discharge pulses in liquid consists of a high voltage transformer and a voltage doubler, which charges a work capacitor battery. The discharging circuit includes a high voltage switch (trigatron) and the discharge gap in the water. The energy characteristics of the discharge pulse have been recorded for all values of the described parameters above. The formed high voltage discharge pulse has a periodically attenuating character. The experimental results have been analyzed by using the following methodology: 1) Defining the discharge process duration; 2) Recording the values of the discharge current and discharge voltage for all maximums of the positive half-wave and the moment of their appearance from the high voltage periodically attenuating oscillations; 3) Drawing the wrap curves from the amplitude values of the discharge current and voltage; 4) Calculation of the liquid medium resistance R_L on the basis of the obtained curves.

At higher capacitance of the work capacitor battery was observed decreasing the resistance and changing of the curve character. The energy characteristics of the periodically attenuating discharge process (discharge current and voltage) are taken down at parameters: capacitance of the work capacitor battery; voltage, to which it is charged to and the temperature of the liquid medium. The liquid resistance alteration for different temperatures of the water during the discharge process is defined. It is proposed a description of the liquid resistance alteration with a mathematical function - third order polynomial. The received results and dependencies can be used for sizing of systems for generation of high voltage discharge pulses for different technological applications.

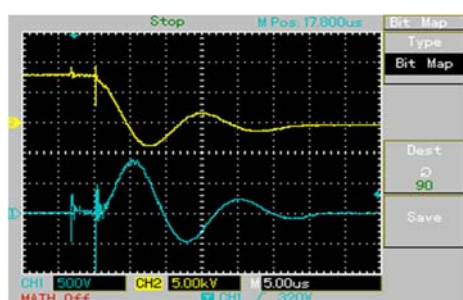


Fig.5 Discharge current and discharge voltage at $C=1\mu\text{F}$, $T=90^\circ\text{C}$, $U_c=9,5\text{kV}$

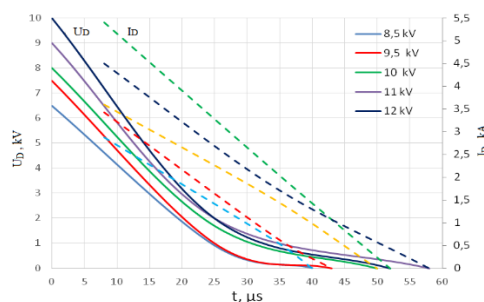


Fig.6 Wrap curves of the amplitude values of the discharge current and voltage at $C=3\mu\text{F}$ and $T=60^\circ\text{C}$.

[10] Vasileva, M., Dimitrova, R., Yordanova, M., Ivanova, M. “Model scheme of the earthing system of electrical power substations for wave processes study”, in 14th International conference on electrical machines, drives and power systems, Proceedings, 2015, Varna, p.114-117, ISSN 1313-4965.

Pulse currents flow through an earthing system in case of direct lightning stroke. This defines a different approach in the modeling and study of the processes in it. The practical interest is aimed at determining the potentials in the area of the earthing system as well as the possible touch and foot voltages.

The purpose of the present paper is to create a simulation model of an earthing grid of electrical power substation with and without vertical earthing rods for defining the maximum possible potentials in the area of the grid at direct lightning stroke.

A model in Matlab Simulink is created for horizontal earthing grid with length 1 m. The proposed module is a base for the creation of an earthing system model of an electrical power substation with size of the site 30x30 m and the cell size – 10 m. The breakdown voltages in the soil are not considered i.e. the transverse dimensions in the replacement scheme (C and g) are with constant values (they do not depend on the voltage). It is accepted that the active resistance of the earthing rod $r = 0,04 / \text{m}$. A lightning is modeled with a current magnitude of 40kA and shape $1/10\mu\text{s}$. Three cases of lightning stroke are considered depending on the place of the stroke at the lightning rods in the earthing grid. The potentials in the corner points of the earthing system are defined for the three cases of lightning stroke for: 1) horizontal grid without vertical earthing rods; 2) horizontal grid with four vertical earthing rods in the corners; 3) horizontal grid with 12 vertical earthing rods placed on the whole grid perimeter.

The received results show that the potentials in the earthing system reach 140kV at the place of lightning stroke and vary between 3 kV and 70 kV in the corners. These results are valid at lightning current magnitude of 40 kA. From the obtained results it can be seen that the process in the earthing system attenuates after 0,1 ms.

The model scheme of the earthing system is suitable for study of the processes in it and in the soil at direct lightning stroke in the lightning rods of the electrical power substation. The scheme could be used for study of the reliable and safe work of the and for investigation of the electrical safety of the staff.

The usage of vertical earthing rods in nodes of the earthing grid significantly decreases the potentials - the reduction is up to tens of times.

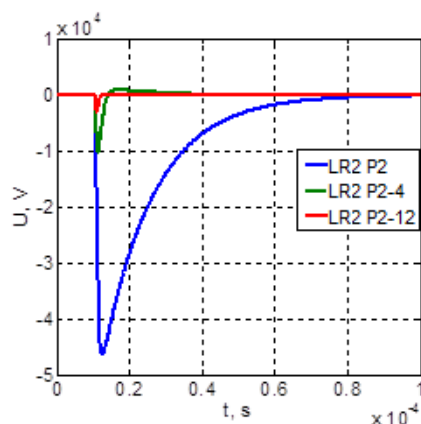


Figure 5. Potentials at point P2, in the case of lightning stroke at LR2, for horizontal grid without vertical earthing rods, with 4 and 12 vertical earthing rods.

- [11] Yordanova M., Dimitrova R., Vasileva M., Ivanova M. “Regression analysis of experimental data for the soil electrical characteristics considering humidity and frequency”, in 1st International Conference “Applied Computer Technologies” ACT 2018, 21-23 June, Ohrid, Macedonia, Proceedings, pp.79-82, ISBN 978-608-66225-0-3.

Soil resistivity ρ and dielectric permittivity ϵ_r directly affect on the parameters of lightning protection and grounding systems for computer modelling of the processes in them at direct lightning strokes. Their frequency dependency is necessary to be considered.

The paper provides an approach for obtaining data for ρ and ϵ_r where a precise analysis of the soil processes at lightning impulses impact is needed. Results from unplanned factor analysis of experimental studies of the electrical characteristics of soils with different humidity, determined at different frequencies, conducted by the authors., have been presented. The experimental results have shown that the great variety of the values of ρ and ϵ_r determines the need for preliminary sampling before commencing the design of a grounding system and subsequently using the regression equations proposed in the paper to find their values at any frequency.

A program developed in the Technical University – Varna (by other researchers) has been used for statistical processing of the experimental data. Equations for determining of the soil resistivity and dielectric permittivity depending on their values at 50Hz, different humidity and density of the soil for frequencies from 100kHz to 1MHz have been obtained by applying a two-variable regression analysis. The regression equations are useful for obtaining estimates of ρ and ϵ_r only for the area of Varna from where the soil samples are taken. The obtained regression equations for determining ρ and ϵ_r from the frequency and their values at 50Hz are suitable for sizing of grounding systems considering the impulse processes in the soil under the impact of lightning impulse current.

Verification of the results authenticity between the experimental and computing results have been performed.



Figure 1. Precision Impedance Analyzers 6500B Series

[12] Ivanova, M., Barudov, E. “Study of the energy characteristics of a system for generation of high-voltage discharge pulses for water treatment with the usage of a discrete alternating voltage regulator”, in IST International conference of Marine Engineering, 21-23 Nov. 2018, NVNA Varna, Bulgaria, pp.63-67, ISBN 978-619-7428-31-5 (pdf)

Systems for generation of high-voltage discharge pulses (SGHVDP) in water, based on capacitive energy accumulation, are widely used in different technological applications, including on ships. Their usage demands control of the discharge pulses frequency in terms of capacity change of the work capacitor battery and the voltage to which it is charged, which is often performed by a thyristor switch. Disadvantages of this type of control are the high level of harmonics and low values of the power factor $\cos \varphi$. The energy characteristics of a SGHVDP based on capacitive energy accumulation can be improved by the usage of a discrete alternating voltage regulator (DAVR) by reducing the interference in the power supply network during the device operation. DAVR gives a possibility for regulating the input voltage amplitude in order to provide less loading on the elements in the circuit for capacitive energy accumulation in SGHVDP and in the shipboard power supply network (SPSN). Suitable charging regimes of the capacitor battery for various technological applications could be provided by changing the step for regulation of the input voltage during the different periods. On specialized ships with electric propulsion systems the work of frequency regulators introduces disturbances in the SPSN.

The work is dedicated to the study of the generated harmonics and the change of the supply voltage amplitude of a SGHVDP for water treatment, based on capacitive energy accumulation with the usage of a DAVR for discharge pulses frequency control. To study the generated harmonics, the parameter THD is determined by using Power Quality Analyzer FLUKE 43B at the input and the output of DAVR during the operation of the SGHVDP in water. The results from the performed analysis at commutation of DAVR also showed that the harmonics levels do not exceed the defined values by IEC 60092-101. An experimental investigation of the effectiveness of DAVR has been conducted in other research, where it was found that when the input voltage is below 180,1 V and the load resistance of the regulator is lower than 5,5 Ω , the consumed reactive power Q_{gen} by DAVR is higher than 2,4kW. In that case, Q_{gen} should be considered when using the system DAVR - SGHVDP in SPSN. Usually, such low values of the supply voltage and load resistance could not be reached in normal operation of the SPSN if the requirements for power quality parameters in shipboard power network are met according to IEC 60092-101. Although, the SPSN has a power compensator and a regulator of $\cos \varphi$, which additionally allows for the drawbacks of using DAVR at small loads to be overcome. In case the output voltage magnitude of DAVR is less than the admissible value for SPSN ($\pm 5\%$), in the control of the switching of the commutation thyristor block could be introduced a system for control of the number and power of the connected loads (if there are other loads than the SGHVDP).

As a summary, the using of a DAVR for control of the SGHVDP for water treatment improves its energy characteristics – reduces the generated high-frequency harmonics and the alteration of the input supply voltage, improves $\cos \varphi$.

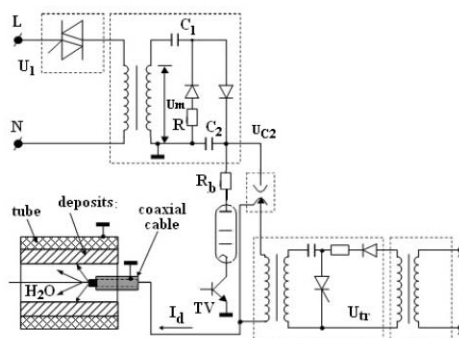


Fig. 1. Device for generation of high-voltage discharge pulses in liquid medium