Stručna komisija 2 (STK 2) / *Expert Committee 2 (EC 2)*

KVALITET ELEKTRIČNE ENERGIJE U ELEKTRODISTRIBUTIVNIM SISTEMIMA
POWER QUALITY IN ELECTRICAL DISTRIBUTION SYSTEMS

Predsednik / *Chairman*:
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U okviru Stručne komisije 2 – Kvalitet električne energije u elektrodistributivnim sistemima CIRED-a SRBIJE za XIV Savetovanje o elektrodistributivnim mrežama (Kopaonik, 16-20. 09. 2024.) predložene su sledeće preferencijalne teme:

1. Kvalitet električne energije (KVEE) i uticaj primene novih tehnologija
    - izobličenja i poremećaji napona i struje, viši harmonici, propadi napona i dr.,
    - uzroci, prostiranje, eliminisanje, analize, iskustva, i dr.,
    - uticaj DER, EV, LED i dr.;
    - KVEE u aktivnim mrežama i mikromrežama, podrška mreži i sl.,
    - DC mreže i KVEE, upravljanje (menadžment) KVEE, interakcija velikih solarnih i vetro elektrana, HVDC, FACTS, i dr.
2. Instrumentacija i metode za merenje i praćenje parametara KVEEod DC do 500 kHz
    - dijagnostičke i merne metode, postupci i sl.,
    - instrumentacija, oprema, integracija, tačnost i dr.,
    - digitalizacija, standardizovanje formata merenja,
    - obrada rezultata merenja, big data, primena AI i dr.
3. Domaća i medjunarodna tehnička regulativa
    - postupci standardizacije, rad komisija za standardizaciju i sl.,
    - domaći i međunarodni standardi, stanje u primeni,
    - aktuelna problematika tehničkih propisa i postupaka, iskustva u primeni,
    - imunitet i pitanja sigurnosti, i dr.
4. Prenaponi/podnaponi i zaštita, elektromagnetna kompatibilnost, bezbednost i interferencija
    - uzroci prenapona/podnapena,
    - zaštita od prenapona u distributivnim mrežama,
    - poremećaji u uzemljenju i uticaj na KVEE i druge povezane teme,
    - nisko-frekventneelektromagnetnesmetnje,
    - uticaj KVEE naživotnivekopremei dr.

Within the Expert Committee 2 – Power Quality in Electrical Distribution Systems of CIRED SERBIA for the 14th Conference on Electricity Distribution (Kopaonik, Sept. 16-20, 2024) the following preferential topics were proposed:

1. Power Quality (PQ) and the impact of the application of new technologies
    - *voltage and current distortions and disturbances, harmonics, voltage sags, etc.,*
    - *causes, spread, elimination, analyses, experiences, etc.,*
    - *influence of DER, EV, LED, etc.;*
    - *PQ in active networks and microgrids, network support, etc.,*
    - *DC networks and PQ, PQ control, interaction of large solar and wind power plants, HVDC, FACTS, etc.*
2. Instrumentation and methods for measuring and monitoring PQ parameters from DC to 500 kHz
    - *diagnostic and measurement methods, procedures, etc.,*
    - *instrumentation, equipment, integration, accuracy, etc.,*
    - *digitalization, standardization of measurement formats,*
    - *processing of measurement results, big data, application of AI, etc.*
3. Domestic and international technical regulations
    - *standardization procedures, work of standardization commissions, etc.,*
    - *domestic and international standards, state of application,*
    - *current issues of technical regulations and procedures, field experiences,*
    - *immunity and security issues, etc.*
4. Over/under voltages and protection, electromagnetic compatibility, safety, and interference
    - *causes of over/under voltages,*
    - *protection against overvoltage in distribution networks,*
    - *grounding disturbances and impact on PQ and other related topics,*
    - *low-frequency electromagnetic disturbances,*
    - *the impact of PQ on the lifetime of equipment, etc.*

Za stručnog izvestioca Stručna komisija 2 odredila je prof. dr Vladimira Katića.

Za STK 2 prijavljeno je devet radova u vidu abstrakta, a u punom obliku dostavljeno je sedam. Svi dostavljeni radovi recenzirani su od strane kompetentnih recenzenata, a nakon recenzije, urađenih ispravki od strane autora i diskusije na Stručnoj komisiji, za izlaganje prihvaćeno je 6 radova kao referati i 1 kao informacija.

Stručna komisija radove je svrstala po preferencijalnim temama i to 4 rada u prvu, 2 rada u drugu i 1 rad u četvrtu preferencijalnu temu.

U pripremanju ovog izveštaja stručni izvestilac je koristio zapažanja, komentare i pitanja recenzenata, na čemu im posebno zahvaljuje.

The Expert Commission 2 appointed Prof. Vladimir Katić, PhD as expert rapporteur.

For the Expert Committee 2, nine applications were submitted as abstracts, while seven were submitted in full form. Competent reviewers reviewed all submitted papers. After the review, corrections made by the authors, and discussion at the Expert Committee, they were accepted for presentation: 6 papers as reports and 1 as information. The Expert committee classified the papers according to preferential topics, namely 4 papers in the first, 2 in the second, and 1 paper in the fourth preferential topic.

In preparing this report, the expert rapporteur used observations, comments, and questions from reviewers, for which he especially thanked them.

STK 2 / *EC 2*: Preferencijalna tema 1 / *Preferential Subject 1*:
Kvalitet električne energije (KVEE) i uticaj primene novih tehnologija / *Power Quality (PQ) and the impact of the application of new technologies*

R-2.01.
ISTRAŽIVANJA KVALITETA ELEKTRIČNE ENERGIJE U SRBIJI - KRATAK PREGLED KROZ RADOVE SAVETOVANJA CIRED SRBIJA
RESEARCH OF THE POWER QUALITY IN SERBIA - SHORT OVERVIEW THROUGH THE CIRED SERBIA CONFERENCES PAPERS

Vladimir Katić

Problematika kvaliteta električne energije u elektrodistributivnim mrežama razmatrana je u sklopu istoimenog studijskog komiteta CIRED Srbije, ranije Jugoslovenskog komiteta CIRED (STK 2) još od prvog savetovanja, davne 1998. god. U ovom dugom periodu od preko dvadeset pet godina, prezentovan je veliki broj saopštenja, referata i informacija iz ove oblasti. Oni predstavljaju svojevrsni odraz stanja razvoja i izučavanja ove tematike u Srbiji i interesantno je osvrnuti se na njih.

U ovom radu dat je kratak pregled najznačajnijih referata sa savetovanja CIRED-a u Srbiji sa ciljem sagledavanja ključne tematike i različitih aspekata istraživanja ove oblasti. Predstavljen je svojevrstan uvid u bavljenje ovom oblašću, kao i korišćenim metodama merenja, načinima otklanjanja poremećaja, primenjenim standardima, iskustvima, studijama slučaja, specifičnim rešenjima i dr. Takođe, dat je i sveobuhvatni pogled na ovu značajnu problematiku savremenih distributivnih električnih mreža u praksi elektrodistributivne delatnosti u Srbiji i istaknut značaj domaćih istraživača na njenom izučavanju. Ovakav pristup je jedinstven u domaćoj literaturi i daje osnove za dalje šire razmatranje stanja razvoja izučavanja ove problematike u Srbiji i regionu.

The issue of the power quality in electrical distribution networks has been discussed within the eponymous study committee CIRED Serbia, formerly the Yugoslav Committee CIRED (STK 2) since the first conference, back in 1998. In this long period of over twenty-five years, a large number of announcements, reports, and information from this field have been presented. They represent a kind of reflection of the state of development and study of this topic in Serbia, and it is interesting to look back at them.

This paper provides a brief overview of the most important reports from the CIRED conference in Serbia to review the key topics and various aspects of research in this area. A kind of insight into dealing with this field is presented, as well as used measurement methods, ways of removing disturbances, applied standards, experiences, case studies, specific solutions, etc. Also, a comprehensive view of this important issue of modern distribution electrical networks in the practice of electricity distribution activity in Serbia was given and the importance of domestic researchers in its study was highlighted. This approach is unique in domestic literature and provides the basis for further broader consideration of the state of development of the study of this issue in Serbia and the region.

Pitanja za diskusiju */ Questions for discussion:*

1. Rad daje pregled najznačajnijih radova u oblasti kvaliteta električne energije kroz duži vremenski period. Kako autor ocenjuje promenu metodologije, i napredak u tehnologijama u oblasti praćenja kvaliteta?

2. Da li su se u ovom periodu značajnije promenili standardni po pitanju dozvoljenih odstupanja, i pooštrili kriterujumi u pitanju kvaliteta?

1. *The paper provides an overview of the most important papers in the field of power quality over a long period. How the author assesses the change in methodology, and the progress in technologies in the field of quality monitoring.*
2. *Have the standards in terms of permissible deviations changed significantly in this period, and the criteria in terms of quality have tightened?*

R-2.02.
KVALITET ELEKTRIČNE ENERGIJE NA MESTU PRIKLJUČENJA SOLARNIH ELEKTRANA NA DISTRIBUTIVNI SISTEM
POWER QUALITY AT THE POINT OF CONNECTION OF SOLAR POWER PLANTS TO THE DISTRIBUTION SYSTEM

Nenad Zlatković, Bojan Đekić, Nikola Krušković

U radu je predstavljena analiza kvaliteta električne energije, kroz kvalitet napona na mestu priključenja solarnih elektrana na distributivni sistem. To je značajno praktično iskustvo i vredan primer rezultata merenja sa terena. Uočeni problem sa visokim vrednostima flikera treba detaljnije analizirati, kao potencijalnu "opasnost" za očekivane buduće slučajeve sa većim brojem priključenih FN elektrana.

The paper presents an analysis of the power quality, through the quality of the voltage at the point of connection of solar power plants to the distribution system. It is a significant practical experience and a valuable example of measurement results from the field. The observed problem with high flicker values should be analyzed in more detail, as a potential "danger" for expected future cases with a larger number of connected FN power plants.

Pitanja za diskusiju */ Questions for discussion:*

1. Objasniti šta bi mogao biti uzrok loših rezultata za fliker u sva tri slučaja. Koliko rezultati odstupaju od specifikacija proizvođača invertora?
2. Da li su razlikovani režimi kada FN elektrana proizvodi za svoje potrebe, a kada je plasira u sistem?
3. Koje su električne karakteristike FN panela i invertora?

1. *Explain what could be the cause of the poor flicker results in all three cases. Do the results deviate from the inverter manufacturer's specifications?*
2. *Are there different regimes when the PV power plant produces for its own needs, and when it places it in the system?*
3. *What are the electrical characteristics of PV panels and inverters?*

R-2.03.
POBOLJŠANJE KVALITETA ELEKTRIČNE ENERGIJE U RAČUNARSKOM CENTRU PRIMENOM AKTIVNOG SHUNT FILTERA
ENHANCING POWER QUALITY IN DATA CENTER THROUGH THE APPLICATION OF ACTIVE SHUNT FILTERS

Aleksandar Tosunović, Nataša Savić

U radu je razmatrana pojava izobličenja mrežne struje kao posledica rada računarskog centra. Prikazni su rezultati merenja u nekoliko tačaka i dati odgovrajući komentari. Rad predstavlja vredno iskustvo o negativnim posledicama rada računarskog centra, ali i o mogućem načinu otklanjanja. Prikazano je da primenom aktivnog filtera praktično se eliminiše strujno izobličenje i omogućuje rad u skladu sa domaćim i međunarodnim standardima.

The article discusses the phenomenon of network current distortion as a consequence of the operation of the computer center. The results of measurements at several points are presented and corresponding comments are given. The paper represents a valuable experience about the negative consequences of the computer center's operation, but also about the possible way to eliminate it. It was shown that the application of an active filter practically eliminates current distortion and enables operation following domestic and international standards.

Pitanja za diskusiju */ Questions for discussion:*

1. Objasnite strukturu računarskog centra sa detaljima o računarima i računarskoj opremi, njihovoj snazi i načinu povezivanja na mrežu. Koje komponente bi bile glavni izvori viših harmonika?

2. U rezultatima harmonijske analize dominiraju 5-ti, 7-mi i 11-ti harmonik, što odgovara harmonijskom izobličenju trofaznog AC pogona. Objasniti odsustvo 3-ćeg i 9-tog harmonika i prokomentarisati prikazane rezultate sa aspekta nelinearnosti računara.
3. Iz rezultata se vidi da rad aktivnog filtera praktično eliminiše harmonijsko izobličenje struje, ali i unosi neke gubitke. Kakva su praktična iskustva njegove primene i šta su glavni postignuti benefiti?

1. *Explain the structure of a computer center detailing computers and computer equipment, their power, and how they are connected to a network. Which components would be the main sources of harmonics?*
2. *The results of the harmonic analysis are dominated by the 5th, 7th, and 11th harmonics, which corresponds to the harmonic distortion of the three-phase AC drive. Explain the absence of the 3rd and 9th harmonics and comment on the displayed results from the aspect of computer nonlinearity.*
3. *It can be seen from the results that the operation of the active filter practically eliminates the harmonic distortion of the current, but also introduces some losses. What are the practical experiences of its application and what are the main benefits achieved?*

I-2.04.
UGRADNJA IZOLOVANE VODONEPROPUSNE STEZALJKE SA INTEGRISANIM OSIGURAČEM NA PRIKLJUČNOM STUBU
INSTALLATION OF FUSED IPC CONNECTOR ON UTILITY POLE

Vladimir Rilak, Milan Radojković, Dejan Bošković

U radu je opisano predloženo rešenje za pojavu lažnih limitatora, posebno kod potrošača u kategoriji "domaćinstva". Rešenje je bazirano na vodonepropusnom osiguraču, koji se montira na priključni vod. Dat je njegov opis, tehničke karakteristike i sertifikat usklađenosti sa medjunarodnim standardima, ako i prikazan primer izgleda ugradjenog.

The paper describes the proposed solution for the appearance of false limiters, especially among consumers in the "household" category. The solution is based on a waterproof fuse, which is mounted on the connection line. Its description, technical characteristics, and certificate of compliance with international standards are given, as well as an example of the built-in appearance.

Pitanja za diskusiju */ Questions for discussion:*

1. Da li postoje slična rešenja na tržištu i koje bi bile kompatarivne prednosti predloženog?
2. Koliko je zahtevna ugradnja predloženog rešenja (zamena postojećeg) i da li je to dodatni trošak za distribuciju?
3. Koliko je složena i koliko traje zamena u slučaju reagovanja osigurača? Koliko ukupno traje intervencija ekipe, tj. koliko dugo potrošač ostaje bez napajanja? Dati neke primere.

1. *Are there similar solutions on the market and what would be the comparative advantages of the proposed one?*
2. *How demanding is the installation of the proposed solution (replacement of the existing one) and is it an additional cost for distribution?*
3. *How complex is it and how long does it take to replace it in the event of a blown fuse? How long does the intervention of the team take in total, i.e. how long does the consumer stay without power? Give some examples.*

STK 2 / *EC 2*: Preferencijalna tema 2 / *Preferential Subject 2*:
Instrumentacija i metode za merenje i praćenje parametara KVEE od DC do 500 kHz / *Instrumentation and methods for measuring and monitoring PQ parameters from DC to 500 kHz*

R-2.05.
METODA ZA ESTIMACIJU UTICAJA PRIKLJUČENJA NOVIH POTROŠAČA NA VREDNOST FLIKERA U DISTRIBUTIVNOJ MREŽI
A METHOD FOR ESTIMATING THE INFLUENCE OF NEW LOADS TO FLICKER VALUES IN DISTRIBUTION GRID

Nikola Laketić, Vladimir Đikić, Vladimir Krnajski, Aleksandar Tatalović

Rad predstavlja inovativnu metodu za estimaciju vrednosti flikera prouzrokovanog radom jednog ili više perspektivnih izvora flikera u distributivnoj i prenosnoj mrežu. Metoda se bazira na proračunu vremenskog profila efektivne vrednosti napona uz korišćenje modela izvora flikera u visokoj vremenskoj rezoluciji i modela prenosne ili distributivne mreže. Metod je verifikovan na rezultatima merenja u realnoj mreži i pokazao je visoku tačnost (greška ispod 5%).

The work presents an innovative method for estimating the value of flicker caused by the operation of one or more prospective sources of flicker in the distribution and transmission network. The method is based on the calculation of the time profile of the effective voltage value with the use of a flicker source model in high-time resolution and a transmission or distribution network model. The method was verified on the results of measurements in a real network and showed high accuracy (error below 5%).

Pitanja za diskusiju */ Questions for discussion:*

1. Koji su negativni efekti pojave flikera u mreži i kako se oni manifestuju na ostale potrošače. Da li ih mogu "osetiti" i potrošači na niskom naponu?
2. Da li je predložena metoda primenljiva samo za potrošače tipa elektrolučne peći ili ima i šire mogućnosti?
3. Da li je potrebno znatno poznavanje (ulaznih) parametara mreže za primenu ove metode i da li to može biti ograničavajući faktor?

1. *What are the negative effects of flickering in the network and how do they affect other loads? Can consumers also "feel" them at low voltage?*
2. *Is the proposed method applicable only to consumers of the electric arc furnace type or does it have wider possibilities?*
3. *Is significant knowledge of (input) network parameters required for the application of this method and can this be a limiting factor?*

R-2.06.
METODE ZE ODREĐIVANJE LIMITA ZA INJEKCIJU POREMEĆAJA U CILJU ODRŽANJA PLANSKIH NIVOA IZOBLIČENJA
METHODS FOR DETERMINING THE LIMITS FOR DISTURBANCE INJECTION IN ORDER TO MAINTAIN THE PLANNED DISTORTION LEVELS

Nikola Laketić, Aleksandar Tatalović, Branka Kovačević

U radu je razmatrano izobličenje mrežnog napona, koje unose nelinearni potrošači, naročito ako ih je prisutno više. Date su osnovne smernice za raspodelu ovih kapaciteta i dodelu limita za injekciju poremećaja perspektivnim potrošačima, na osnovu važećih IEC preporuka. Razmotreni su potencijalni problemi primene ovakve strategije u domaćoj praksi. Date su okvirne preporuke šta bi, u domaćoj praksi, trebalo da obuhvati procedura za priključenje novih potrošača u cilju očuvanja planskih nivoa poremećaja u distributivnu mrežu.

The paper discusses the distortion of the network voltage, which is introduced by non-linear consumers, especially if there are more. Basic guidelines are provided for the distribution of these capacities. Also, the allocation of limits for their injection to prospective consumers, based on valid IEC recommendations is discussed. Potential problems in applying this strategy in domestic practice were considered. Outline recommendations were given as to what, in domestic practice, the procedure for connecting new consumers should include preserving the planned levels of disturbances in the distribution network.

Pitanja za diskusiju */ Questions for discussion:*

1. U svetu je poznato više pristupa problemu korišćenja prava harmonijskog kapaciteta mreže. U USA je ranije primenjivan princip “first come, first served”, odnosno da se potrošačima daje pravo korišćenja ovog kapaciteta po redosledu priključivanja. Kakva je sada praksa u svetu, nakon sve šireg prisustva OIE u mreži i sve većeg broja nelinearnih potrošača?
2. U literaturi je u mnogim radovima razmatran harmonijski doprinos nelinearnih potrošača i njihov doprinos (udeo) ukupnom izobličenju napona mreže. Na primer, u radu https://doi.org/10.1007/978-3-319-47295-9_5 razmatrano je pitanje maksimalnog broja (ili snage) nelinearnih potrošača (računara), koji NN mreža može da podnese, a da naponsko izobličenje ne premaši standardom limitiranu vrednost. Da li se slična procena može uraditi i za primer dat u radu za svakog pojedinačnog potrošača? Kako bi takva procena mogla da posluži u budućoj raspodeli korišćenja harmonisjkih kapaciteta?
3. U radu je konstatovano da “jedino operator mreže može koordinisati sve potrošače i primenjene mere kako bi se došlo do dugoročnog rešenja prihvatljivog za sve strane.“ Kako bi to operator praktično radio? Ako bi trebalo intervenisati na smanjenju izobličenja, koji potrošač, od više njih, bi trebao da smanji svoj negativni uticaj ulaganjem u mere zaštite? Kako bi se to odredjivalo i ko bi snosio troškove?

1. *Several approaches to the problem of using the right of harmonic network capacity are known in the world. In the USA, the "first come, first served" principle was previously applied, that is, consumers are given the right to use this capacity in the order of connection. What is the current practice in the world, after the increasing presence of RES in the network and the increasing number of non-linear consumers?*
2. *In the literature, the harmonic contribution of non-linear consumers and their contribution (share) to the total distortion of the network voltage have been discussed in many papers. For example, in the paper https://doi.org/10.1007/978-3-319-47295-9_5, the issue of the maximum number (or power) of non-linear consumers (computers), which the LV network can handle, and the voltage distortion does not exceed the value limited by the standard. Can a similar assessment be made for each consumer in*

the example given in the paper? How could such an assessment serve in the future distribution of the use of harmonic capacities?

3. *The paper stated that "only the network operator can coordinate all consumers and apply measures to reach a long-term solution acceptable to all parties." How would the operator practically do that? If intervention were to be done to reduce distortions, which consumer, among several, should reduce their negative impact by investing in protective measures? How would it be determined and who would bear the costs?*

STK 2 / *EC 2*: Preferencijalna tema 4 / *Preferential Subject 4*:
Prenaponi/podnaponi i zaštita, elektromagnetna kompatibilnost, bezbednost i interferencija / *Over/under voltages and protection, electromagnetic compatibility, safety, and interference*

R-2.07.
UZEMLJENJE VISOKONAPONSKE TRAFOSTANICE U NEPOVOLJNIM USLOVIMA
GROUNDING OF A HIGH VOLTAGE SUBSTATION IN UNFAVORABLE CONDITIONS

Pande Popovski, Goran Veljanovski, Nikolche Acevski, Metodija Atanasovski

U radu je obrađeno projektovanje rešenja za uzemljenje za novu visokonaponsku trafostanicu u suboptimalnim uslovima. Tačnije, konvencionalni dizajn nije mogao biti razvijen zbog prostornih ograničenja oko zgrade trafostanice. Potrebna je detaljna analiza, uzimajući u obzir različite scenarije i rešenja za sistem uzemljenja.
Nakon nekoliko iteracija, postignut je konačni dizajn mreže. Pored projektovanja, zaključeno je da treba preduzeti još nekoliko mera kako bi se izbegle opasnosti prilikom kvara na bilo kojoj trafostanici.

The paper covered designing a grounding solution for a new high-voltage substation in sub-optimal conditions. More precisely, a conventional design could not be developed because of the spatial constraints around the substation's building. A detailed analysis was required, taking into account different scenarios and solutions for the grounding system.
After several iterations, the final ground grid design was achieved. Besides the design, it was concluded that several other measures should be taken to avoid any dangers during a fault at any one of the substations.

Pitanja za diskusiju */ Questions for discussion:*

1. Treba objasniti šta se podrazumeva pod „nepovoljni uslovi“. Da li su ovi uslovi karakteristični za ovaj, određeni dizajn, ili metoda ima širu primenu?
2. Dajte komentare na dobijene rezultate prikazane u tabelama 2.3 i 2.5.
3. Neke preporuke su date u odeljku Zaključak. Međutim, možete li biti konkretniji i dodati neke praktične detalje?

1. *The "unfavorable conditions" should be explained. Are these conditions characteristic of this, particular design, or does the method have a wider application?*
2. *Give comments on the obtained results presented in Tables 2.3 and 2.5.*
3. *Some recommendations are given in the Conclusion section. However, can you be more specific and add some practical details?*