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Broj: 02/1-566/1
Datum: 22. 04. 2019

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O V D J E

U prilogu dostavljamo Odluku Vijeća Elektrotehničkog fakulteta sa sjednice od 22.04.2019. godine i obrazac **D2**, sa pratećom dokumentacijom, za kandidata mr **Armenda Ymerija**, na dalji postupak.

Univerzitet Crne Gore Elektrotehnički fakultet

DEKAN,
Prof. dr Zoran Veljović

ISPUNJENOST USLOVA DOKTORANDA

OPŠTI PODACI O DOKTORANDU			
Titula, ime, ime roditelja, prezime	Mr Sci, Armend, Hasan, Ymeri		
Fakultet	Elektrotehnički fakultet Podgorica		
Studijski program	Energetika i automatika		
Broj indeksa	1/13		
NAZIV DOKTORSKE DISERTACIJE			
Na službenom jeziku	Izbor optimalne lokacije i kapaciteta fotonaponskih sistema u cilju smanjenja gubitaka snage i padova napona u distributivnoj mreži		
Na engleskom jeziku	Optimal location and sizing of photovoltaic systems aimed at reduction of power losses and voltage drops in the distribution grid		
Naučna oblast	Elektroenergetika, Elektroenergetski sistemi		
MENTOR/MENTORI			
Prvi mentor	Prof. dr Saša Mujović	Univerzitet Crne Gore, Elektrotehnički fakultet Podgorica, Crna Gora	Elektroenergetika, Elektroenergetski sistemi
Drugi mentor	Prof. dr Vladan Vujičić	Univerzitet Crne Gore, Elektrotehnički fakultet Podgorica, Crna Gora	Elektroenergetika, Energetska elektronika
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Prof. dr Saša Mujović		Univerzitet Crne Gore, Elektrotehnički fakultet Podgorica, Crna Gora	Elektroenergetika, Elektroenergetski sistemi
Prof. dr Vladan Vujičić		Univerzitet Crne Gore, Elektrotehnički fakultet Podgorica, Crna Gora	Elektroenergetika, Energetska elektronika
Prof. dr Vesna Popović-Bugarin		Univerzitet Crne Gore, Elektrotehnički fakultet Podgorica, Crna Gora	Elektronika, Digitalna obrada signala
Doc. dr Samir Avdaković		Univerzitet u Sarajevu, Elektrotehnički fakultet, Bosna i Hercegovina	Elektroenergetika, Elektroenergetski sistemi

Datum značajni za ocjenu doktorske disertacije	
Sjednica Senata na kojoj je data saglasnost na ocjenu teme i kandidata	15.10.2015. godine
Dostavljanja doktorske disertacije organizacionoj jedinici i saglasanost mentora	02.04.2019. godine 02.04.2019. godine
Sjednica Vijeća organizacione jedinice na kojoj je dat prijedlog za imenovanje komisija za pregled i ocjenu doktorske disertacije	22.04.2019. godine

ISPUNJENOST USLOVA DOKTORANDA
U skladu sa članom 38 pravila doktorskih studija kandidat **je** dio sopstvenih istraživanja vezanih za doktorsku disertaciju publikovao u časopisu sa **(SCI/SCIE)/(SSCI/A&HCI)** liste kao prvi autor.
Spisak radova doktoranda iz oblasti doktorskih studija koje je publikovao u časopisima sa (upisati odgovarajuću listu)
[1] Ymeri, A., Mujović, S. (2017) Optimal Location and Sizing of Photovoltaic Systems in Order to Reduce Power Losses and Voltage Drops in the Distribution Grid, International Review of Electrical Engineering, 12 (6): 498-504. ISSN: 1827-6660, EISSN: 2533-2244. DOI: https://doi.org/10.15866/iree.v12i6.12553. [2] Ymeri, A., Mujović, S. (2018) Impact of Photovoltaic Systems Placement and Sizing on Power Quality in Distribution Network. Advances in Electrical and Computer Engineering, 18 (4): 107-112. ISSN: 1582-7445. DOI: 10.4316/AECE.2018.04013. **(SCI/SCIE)**
Obrazloženje mentora o korišćenju doktorske disertacije u publikovanim radovima
Navedeni radovi, od kojih je posebno važan drugi rad, jer je publikovan u časopisu sa SCIE liste, sadrže ključne analize i rezultate date u doktorskoj disertaciji. S tim u vezi, u [1] je prikazan način definisanja optimalne lokacije fotonaponskog generatora na distributivnom vodu, kako bi bili zadovoljeni kriterijumi minimalnih gubitaka snage i padova napona. U cilju optimizacije korištene su metode Decision Tree i genetskog algoritma, kao što je slučaj i u samoj disertaciji. Referenca [2] se bavi analizom uticaja odabrane lokacije i kapaciteta fotonaponskog generatora na parametre kvaliteta električne energije. Dobijeni rezultati se oslanjaju na primjenu metoda Decision Tree i genetskog algoritma, kao i simulacionog softvera DigSilent Power Factory, i u potpunoj su korelaciji sa rezultatima datih u poglavlju 5 doktorske disertacije.
Datum i ovjera (pečat i potpis odgovorne osobe)
U Podgorici, 22.04.2019. godine UNIVERZITET CRNE GORE Elektrotehnički fakultet — MP — DEKAN

Prilog dokumenta sadrži:

1. Potvrdu o predaji doktorske disertacije organizacionoj jedinici
2. Odluku o imenovanju komisije za pregled i ocjenu doktorske disertacije
3. Kopiju rada publikovanog u časopisu sa odgovarajuće liste
4. Biografiju i bibliografiju kandidata
5. Biografiju i bibliografiju članova komisije za pregled i ocjenu doktorske disertacije sa potvrdom o izboru u odgovarajuće akademsko zvanje i potvrdom da barem jedan član komisije nije u radnom odnosu na Univerzitetu Crne Gore

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Broj: 02/1-478
Datum: 03.04.2019.

Na osnovu službene evidencije i dokumentacije Elektrotehničkog fakulteta u Podgorici, izdaje se

P O T V R D A

Mr Armend Ymeri, student doktorskih studija na Elektrotehničkom fakultetu u Podgorici, dana 02.04.2019. godine dostavio je ovom Fakultetu doktorsku disertaciju pod nazivom: „Izbor optimalne lokacije i kapaciteta fotonaponskih sistema u cilju smanjenja gubitaka snage i padova napona u distributivnoj mreži“, na dalji postupak.

D E K A N,

Prof. dr Zoran Veljović

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Broj: 02/1-566
Datum: 22.04.2019

Na osnovu člana 64 Statuta Univerziteta Crne Gore, u vezi sa članom 55 Pravila doktorskih studija, na predlog Komisije za doktorske studije, Vijeće Elektrotehničkog fakulteta u Podgorici, na sjednici od 22.04.2019. godine, donijelo je

O D L U K U

I Utvrđuje se da su ispunjeni uslovi iz Pravila doktorskih studija za dalji rad na doktorskoj disertaciji **„Izbor optimalne lokacije i kapaciteta fotonaponskih sistema u cilju smanjenja gubitaka snage i padova napona u distributivnoj mreži"** kandidata mr **Armenda Ymerija.**

II Predlaže se Komisija za ocjenu navedene doktorske disertacije, u sastavu:

1. Dr Saša Mujović, vanredni profesor Elektrotehničkog fakulteta Univerziteta Crne Gore,
2. Dr Vladan Vujičić, redovni profesor Elektrotehničkog fakulteta Univerziteta Crne Gore,
3. Dr Vladan Radulović, vanredni profesor Elektrotehničkog fakulteta Univerziteta Crne Gore,
4. Dr Vesna Popović-Bugarin, vanredni profesor Elektrotehničkog fakulteta Univerziteta Crne Gore,
5. Dr Samir Avdaković, docent Elektrotehničkog fakulteta Univerziteta u Sarajevu.

Komisija iz tačke II ove Odluke podnijeće Izvještaj Vijeću Fakulteta u roku od 45 dana od dana imenovanja.

-VIJEĆE ELEKTROTEHNIČKOG FAKULTETA-

Univerzitet Crne Gore UCG Elektrotehnički fakultet

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Prof. dr Zoran Veljović

Dostavljeno:
- Senatu,
- Centru za doktorske studije,
- u dosije,
- a/a.

RADOVI SA REZULTATIMA IZ DOKTORSKE TEZE

1. Armend Ymeri, Saša Mujović, “Optimal Location and Sizing of Photovoltaic Systems in Order to Reduce Power Losses and Voltage Drops in the Distribution Grid”, International Review of Electrical Engineering (IREE), Vol.12, N. 6, November–December 2017, ISSN 1827- 6660, DOI: 10.15866/IREE.v12i6.12553.

RADOVI OBJAVLJENI U ČASOPISIMA IZ SCI BAZE (Sa nenultim Impact Factor-om)

1. Armend Ymeri, Saša Mujović, “Impact of Photovoltaic Systems Placement, Sizing on Power Quality in Distribution Network”, Advances in Electrical and Computer Engineering, Vol. 18, N. 4, 2018, ISSN 1582- 7445, DOI: 10.4316/AECE.2018.04013.

Impact of Photovoltaic Systems Placement, Sizing on Power Quality in Distribution Network

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***Abstract*—The paper presents a Decision Tree Algorithm for impact of photovoltaic systems placement and sizing in order to improve power quality in distribution networks. The proposed approach is based primarily on ID3 and J48 Decision Tree Algorithms. With these algorithms, for different sizes of photovoltaic systems, can be defined the optimal location as well as minimal power losses of the distribution network. The simulations were carried out with real data obtained from the Kosovo Distribution Network and visualized with WEKA Toolbox. The obtained results compared with Genetic Algorithm MATLAB toolbox and DIGSILENT/Power factory software, prove tbat the Decision Tree Algorithm works well with an cxcellent and fast accuracy. The results from the application of the proposed mcthod showed reduced power losses and optimal location in the distribution network confirmed method's validity. This approach can be used by engineers, electric utilities and distribution network operators for a quick decision with more efficient integration of new photovoltaic systems in the current distribution networks.**

***Index Terms*—distributed power generation, genetic algorithms, photovoltaic systems, power quality, power systems.**

I. Introduction

Distributed power generations are small electricity producers located near the consumption and load. Their production capacities can range from several kW to several MW and are directly connected to the distribution radial network. Distributed generations (DG) can be classified into four categories:

1. Micro DG with a power capacity of 1 W – 5 kW,
2. Small DG with a power capacity of 5 kW - 5 MW,
3. Medium DG with a power capacity of 5 - 50 MW,
4. Large DG with a power capacity of 50 - 300 MW.

DG is not a new concept and by definition, small size generator. The main idea behind a DG is that generation is done in a small scale and can be easily placed closer to the point of consumption [1]. The presence of the DG changes the power flow and load characteristics of the distribution network. It gradually becomes an active load network. A critical review of the various impacts, such as technical, economic and environmental resulting from the integration of DG in the distribution network as in [2].

DG has the potential to reduce emissions and increase dependence on alternative energy sources and hence, participate at energy diversification. It also helps to deliver backup power during the times of increased electricity demand, having also as a result the reduction of the distribution power losses [3].

An analysis for DG planning, optimal sizing and location is made on the basis of power loss minimization, system cost minimization and system energy loss minimization [4]. Usually, DGs are integrated with the existing distribution system and a lot of studies are done to find out the best location and size of DGs to produce the highest benefits.

Different technologies are used for DG sources such as Photovoltaic (PV) systems, wind generation, combustion engines, fuel eells, etc.

The positive effects of PV systems on the distribution network are: Free solar energy, environmental friendliness avoiding emissions, the possibility to supply places where power systems have not been built, high reliability, easiness in use and low operating costs.

It is necessary for the development of the distribution network to predict, as accurately as possible, the impact of PV systems so that consumers could be provided with a satisfactory electricity quality and at the same time, strive to minimize the losses. Accordingly, the optimal allocation of PV systems and their sizing is pivotal and several approaches have been proposed in the literature.

Optimization is applied in the deregulated power industry finding the best allocation of DG and other devices. There are four major optimization techniques/methodologies available for the distribution system planning in the presence of DG as: Analytical approaches, Conventional optimization programming techniques, Artificial intelligent search techniques and Hybrid based techniques [5].

The analytical method is a simple and non-iterative approach which provides an approximate solution in case of complex problems. This method is not successful in finding solutions for real problems and as such, it is used in rare situations [6]. An analytical method described in [7] computes the optimal location and size of multiple DGs, considering also different types of DGs.

Conventional optimization programming techniques are very good at providing the optimal allocation of PV systems with same/different size in a distribution grid. These methods offer better solutions compared to analytical methods but calculation time is longer.

The digital simulation and electrical network calculation program DIGSILENT/Power factory, in [8] is used to analyze the impact of multi DGs in terms of power losses when they are employed in the distribution network. When the DG is installed close to a substation, active power line losses are reduced. However, if DG's capacity is large and is in a long distance from the substation, active power line losses tend to increase as in [9].

Artificial intelligent search techniques for planning of DG in distribution grid may offer flexible and simplified solutions with a compromise between solution quality and computation time. Artificial intelligent (Heuristic) methods usually give an almost optimal solution in cases when there is only one method, but they require high-tech efforts. These methods are used more in complex problems which cannot be well mathematically described or cannot be solved through conventional methods. The most frequently used techniques are the Genetic Algorithm (GA) and various practical heuristic algorithms. The GA offers a new and powerful approach to these optimization problems which are made possible by increasing the availability of high computers performance at relatively low cost, as in [10].

Meta-heuristic methods are algorithms that add a stochastic factor to the solutions they find. These algorithms are generally known as techniques that do not depend on the problem and do not take advantage of the problem particularities. A description of the main meta-heuristic methods implemented in the determination of the location and/or sizing of the DG, is given in [11].

Influences of DG on the losses after its connection to the distribution network is treated as a special load which can output as active power, as in [12]. However, in the practical application, DG cannot be simply treated as the load which can output active power.

The goal of the algorithm for the individual allocation of DG units based on average daily power consumption and production curves was the minimization of cumulative average daily active power losses [13]. Using the proposed algorithm, the obtained DG allocation results are more detailed and precise, which in turn can have a great importance in avoiding unnecessary and often quite considerable costs in the distribution system operator.

A hybrid of two or more approaches can, however, offer a better solution by incorporating benefits of each and discarding their draw-backs. An optimization method based on Artificial Neural Networks (ANN) and GA is proposed for the determination of size and location of DG in radial and network distribution systems as well as for the reduction of active power losses and voltage profile improvement. ANNs have the ability to solve non-linear mathematical problems extremely quickly and precisely [14].

GA MATLAB toolbox is used in [15] for determining the optimum number of DG units installed in the distribution network with optimal power losses. The best results are obtained with a combination of the three methodologies with proper ratios i.e. reconfiguration of the network, installation of capacitor banks and DG units, altogether leading to a total loss reduction and, at the same time, maintaining the minimum bus voltage profile and reducing branch currents.

GA has the ability to solve nonlinear mathematical problems extremely quickly and precisely. One of the main reasons for using GA is its effectiveness during optimization, especially in cases for various constraints. In [16], an optimization method based on GA MATLAB Toolbox is performed to demonstrate how successfully this method could be used to determinate the size and location of PV systems. At the same time, this method is used to demonstrate the reduction of active power losses and voltage drops.

A decision-making algorithm has been developed for the optimum size and placement of DG units in distribution networks [17]. The proposed algorithm has been tested on the IEEE 33-bus radial distribution system and the obtained results have been compared with those of earlier studies, proving that the decision-making algorithm is well working and has an acceptable accuracy.

The location of PV systems can be determined by the local conditions (land, users), as well as these conditions do not endanger the proposed optimal solution.

The proposed approach is an optimization technique for optimal allocation of the PV systems within the distribution network for the given capacity. The algorithm used in this approach can estimate the optimal location for PV systems and can find the optimum PV size to be installed based on the reduction of power losses.

This approach works well and has an acceptable accuracy and it has been tested on the real radial distribution system. The results obtained in this paper by using Decision Tree Algorithm are compared to the results provided by GA MATLAB toolbox, in a real-time case.

The paper is structured as follows: Problem Formulation presented in section 2; Decision Tree Algorithm for optimal placement and sizing of PV systems presented in section 3; Losses estimation by Decision Tree Algorithm presented in section 4, Application of Decision Tree Algorithm in Distribution system and comparison results presented in section 5; and Conclusions of this paper are summarized in section 6.

II. The Problem Formulation

The main goal of this paper is to study the optimal placement and sizing of PV systems based on the reduction of active power losses in the distribution network. Active power losses exist at generation, transmission and distribution systems. Most of them occur in the distribution systems because of the low voltage, high current levels and radial configuration of these systems [16].

A. Power losses analysis without DG

Power line losses occur when current flows through the distribution grid and they depend on the current amount and resistance. Referring to literature as in [11], [15], the mathematical model for the calculation of power line losses for the case without DG in the distribution line can be calculated by equation (1):

$$P_{LossL} = 3I_L^2 rL \quad (1)$$

where IL is the line current, r the line electrical resistance per unit of length, L the distance between substation and load.

Losses for a three-phase system without DGs can be expressed as in (2):

$$P_{LossL} = \frac{rL(P_L^2 + Q_L^2)}{3V_L^2} \quad (2)$$

where PL is the active power line, QL the reactive power line, VL the load voltage.

B. Power losses analysis with DG

When DG is connected in the distribution network, power losses are calculated by a combination of power line losses from the source to the DG (P_{LossSG}) and power losses from the location of DG to the load location (P_{LossGL}), as in (3) and (4):

$$P_{LossSG} = \frac{rG(P_L^2 + Q_L^2 + P_G^2 + Q_G^2 - 2P_L P_G - 2Q_L Q_G)}{3V_L^2} \quad (3)$$

$$P_{LossGL} = \frac{r(P_L^2 + Q_L^2)}{3V_L^2}(L - G) \quad (4)$$

where PG is the active power of DG, QG the reactive power of DG, G the distance between substation and DG.

The total line loss (P_{LossAT}) in presence of DG can be calculated by combining equations (3) and (4) and are expressed as in (5):

$$P_{LossAT} = \frac{rL[P_L^2 + Q_L^2 + (P_G^2 + Q_G^2 - 2P_L P_G - 2Q_L Q_G)\frac{G}{L}]}{3V_L^2} \quad (5)$$

Loss reduction or instantaneous loss savings ΔP_{LOSS} at any point on a feeder can be represented as the difference between losses without DG and losses with DG as in (6), (7) and they can be positive or negative:

$$\Delta P_{LOSS} = P_{LossL} - P_{LosssAT} \quad (6)$$

$$\Delta P_{LOSS} = \frac{rG(P_G^2 + Q_G^2 - 2P_L P_G - 2Q_L Q_G)}{3V_L^2} \quad (7)$$

When the loss in the system is reduced, then ΔP_{LOSS} has the positive sign and, if not, it is indicated with the negative sign. It indicates that DG causes the system loss to increase [18], [19].

If the location and installed power of the DG are chosen to fit the size and location of the load, it will help to reduce power losses in the line.

III. Decision Tree Algorithm for Optimal Placement and Sizing of PV Systems

Decision Tree Algorithms provide an effective method of Decision Making because it clearly lays out the problem so that all options can be challenged. This method allows analyzing fully the possible consequences of a decision and provide a framework to quantify the values of the outcomes and the probabilities of achieving them.

Decision Tree is a popular classifier that does not require any knowledge or parameter setting. The approach is a supervised learning. Given a training data, we can induce a Decision Tree. From a Decision Tree, we can easily create rules about the data. Using Decision Tree, we can easily predict the classification of unseen records.

Decision Tree is a hierarchical tree structure that used to classify classes based on a series of questions (or rules) about the attributes of the classes. The attributes of the classes can be any type of variables from binary, nominal, ordinal and quantitative values. While the classes must be of qualitative type (categorical or binary, or ordinal).

Decision Tree builds classification or regression models in the form of a tree structure. It breaks down a dataset into smaller subsers while at the same time an associated Decision Tree is incrementally developed. The final result is a tree with decision nodes and leaf nodes. A decision node has two or more branches. Leaf node represents a classification or decision. The topmost decision node in a tree which corresponds to the best predictor called root node. Decision Trees can handle both categorical and numerical data.

The general motive of using Decision Tree is to create a training model which can be used to predict the class or the value of target variables by learning the decision rules inferred from prior data (training data). The Decision Tree Algorithm tries to solve the problem, by using tree representation.

The main goal of regression algorithms is to predict the discrete or a continuous value. In our case, the problem deals with continuous values.

The core algorithm for building Decision Tree used in this paper is based on ID3 and J 48 that uses Entropy and Information Gain to construct a Decision Tree.

A. Entropy

A Decision Tree Algorithm is built top-down from a root node and involves partitioning the data into subsets that contain instances with similar values (homogenous). The ID3 and J48 algorithms use entropy to calculate the homogeneity of a sample. If the sample is completely homogeneous the entropy is zero and if the sample is an equally divided it has an entropy of one. Entropy calculation is presented in (8).

$$H(x) = E_x[I(x)] = -\sum_{x \in X} p(x) \log p(x) \quad (8)$$

B. Information Gain

By using information gain as a criterion, we try to estimate the information contained by each attribute.

By calculating entropy measure of each attribute we can calculate their information gain. Information gain calculates the expected reduction in entropy due to the sorting on the attribute. Information gain can be calculated.

The information gain is based on the decrease in entropy after a dataset is split on an attribute. Constructing a Decision Tree is all about finding an attribute that returns the highest information gain (i.e., the most homogeneous branches).

Decision Trees Algorithm often mimic the human level thinking so it is so simple to understand the data and make some good interpretations.

The next step to determine the correct solution for minimizing active power losses is to choose the appropriate location and size of PV systems for implementation. This is done by using the above-explained Decision Tree Algorithm as presented in Fig. 1.

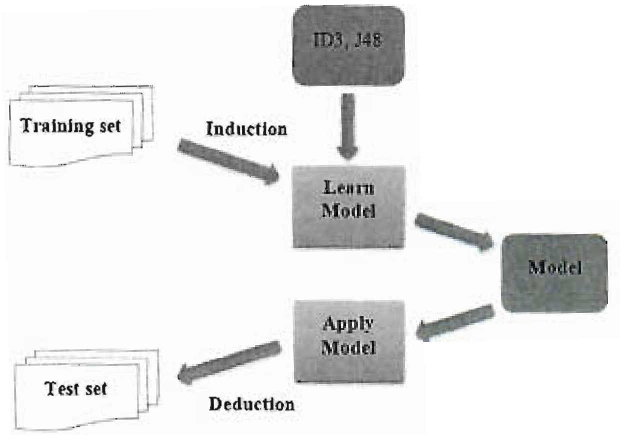

Figure 1. Flowchart of the Decision making algorithm

IV. Losses Estimation by Decision Tree Algorithm

In order to achieve the best location and sizing of PV systems in the distribution network as minimal power losses in 10 kV line, the ID 3 and J 48 algorithms are applied on a part of distribution grid of KEDS (Kosovo Electricity Distribution and Supply), as presented in Table I.

TABLE I. DATA OF 10 KV LINE

Terminal	Distance (km)	Load (MW)
1	3.35	0.012
2	4.62	0.198
3	1.7	0.503
4	6.36	0.775
5	9.99	1.076

The length of 10 kV line "Muciverc" is L =26.02 km and total peak power demand in this line is 2.564 MVA [20]. Based on the simulation carried out during September 2013, by running the power flow calculation in DIGSILENT/Power factory software, the results of power line losses in the case without PV systems are ΔP=0.4514MW as shown in Table II.

TABLE II. POWER LOSSES WITHOUT PV SYSTEMS

Terminal	Losses
1	0.0000008
2	0.00551
3	0.0107
4	0.101
5	0.334
Total:	0.451

When a PV system is connected in a terminal of the 10 kV line "Muciverc" with installed capacity of PV systems from 0.4 MW to 4 MW is presented in Fig. 2.

According to data from calculation in DIGSILENT/Power factory software, the results of power line losses in all terminals by changing the location of the PV systems but keeping the same size, in four cases (0.4 MW, 1 MW, 2 MW and 4 MW) are smaller than in the case without PV systems, as shown in Table III.

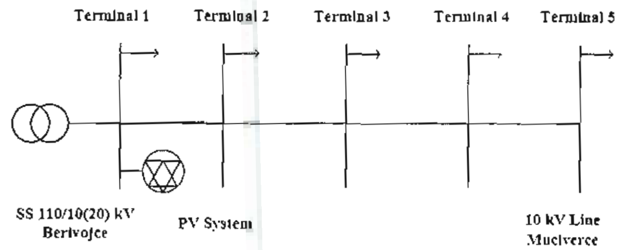

Figure 2. Single line diagram of 10 kV line with PV Systems

TABLE III. POWER LOSSES WITH PV SYSTEMS

Terminal	PV capacity 0.4 (MW)	PV capacity 1 (MW)	PV capacity 2 (MW)	PV capacity 4 (MW)
1	0.442	0.431	0.423	0.438
2	0.429	0.404	0.383	0.421
3	0.424	0.394	0.368	0.414
4	0.406	0.356	0.314	0.390
5	0.401	0.344	0.297	0.383

In order to achieve the best location of PV systems in the distribution network for the given active power losses and for PV system capacity, we use a Decision Tree approach.

Firstly, we define our training data with two attributes PV capacity and P_{LOSS} and Terminal as a decision class. The values for the attributes are presented in Fig. 3 for PV apacity = {VLC, LC, MC, OC, HC} and P_{LOSS} = {L, M, H, EH}.

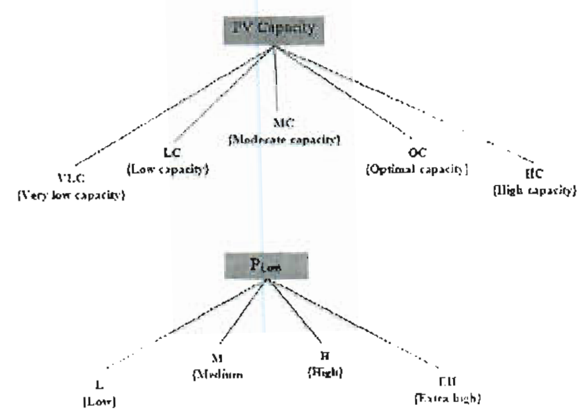

Figure 3. Attributes of ID 3 Algorithm

Since we are dealing with continuous training data, we apply Global Discretization process for P_{LOSS} as presented in Table IV.

TABLE IV. GLOBAL DISCRETIZATION FOR P_{LOSS}

Attribute	P_{LOSS}	Range
EH	Extra high	ΔP>0.414
H	High	0.414>=ΔP>0.383
M	Medium	0.383>=ΔP>0.297
L	Low	0.297=ΔP

Global Discretization process for PV capacity is presented in Table V.

TABLE V. GLOBAL DISCRETIZATION FOR PV CAPACITY

Attribute	PV Capacity	Range
VLC	Very Low Capacity	0<PV<=0.4
LC	Low Capacity	0.4<PV<=1
MC	Moderate Capacity	1<PV<=2
OC	Optimal Capacity	2<PV<=2.564
HC	High Capacity	2.564<PV<=4

For a demonstration, we will show some of the training data in Table VI.

TABLE VI. SET OF TRAINING DATA

PV Capacity	P_{LOSS}	Classes (terminal)
MC	L	Five
MC	M	Four
LC	M	Five
LC	M	Four
MC	M	Three
HC	M	Five
MC	M	Two
HC	H	Four
LC	H	Three
VLC	H	Five
LC	H	Two
VLC	H	Four
HC	H	Three
HC	EH	Two
MC	EH	One
VLC	EH	Three
VLC	EH	Two
LC	EH	One
HC	EH	One
VLC	EH	One
OC	L	Five

Based on these training data we can induce a decision tree as in Fig. 4.

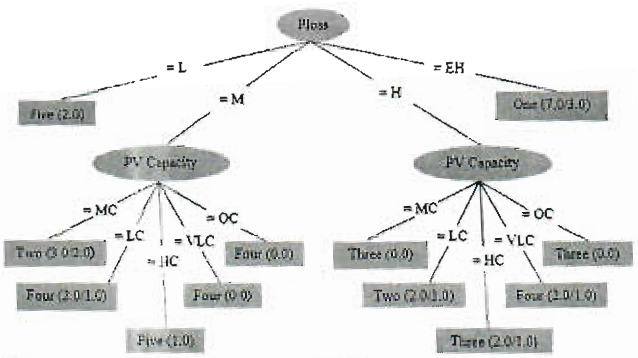

Figure 4. Visualized Decision Tree algorithm

V. APPLICATION OF DECISION TREE ALGORITHM IN DISTRIBUTION SYSTEM AND COMPARISON OF RESULTS

Decision Tree Algorithm and GA MATLAB toolbox use the same database. By running Decision Tree Algorithm on a set of variables for a selected terminal and by running the power flow calculation in DIGSILENT/Power factory and GA MATLAB toolbox with the same PV systems values, the results can be compared and evaluated. We use the real case scenarios data, based on the simulation by running the power flow calculation in DIGSILENT/Power factory and GA MATLAB Toolbox.

GA MATLAB toolbox has reached an optimal solution with 50 iteration (see Table VII). According to the outputs, the optimal location for a PV system is terminal 5, while the values for the corresponding size and total power losses for the given load are 2.564 MW and 0.248 MW, respectively.

TABLE VII. GA ALGORITHM OUTPUTS

GA Outputs	Best Value
PV System capacity (MW)	2.564
Active Power Losses (MW)	0.248

The performance of the Decision Tree Algorithm is acceptable. The comparison of the results given by GA MATLAB toolbox show that the Decision Tree determines the valid value of active power losses. The results of the Decision Making, generally match the results provided by GA MATLAB toolbox. The results are compared by calculating each terminal with different PV systems capacities (from 0.4 MW to 4 MW).

In particular, the experimental data for the cases with PV Systems are used as training data for our Decision Tree Algorithm, as in Fig. 5.

Terminal	Power Losses (MW) PV Systems capacity			
	0.4 MW	1 MW	2 MW	4 MW
1	0.442	0.431	0.422	0.438
2	0.429	0.404	0.382	0.420
3	0.424	0.394	0.368	0.414
4	0.406	0.356	0.313	0.390
5	0.401	0.344	0.297	0.382

↓

Terminal	Power Losses (MW) PV Systems capacity			
	VLC	LC	MC	HC
One	EH	EH	EH	EH
Two	EH	H	M	EH
Three	EH	H	M	H
Four	H	M	M	H
Five	H	M	L	M

Figure 5. Decision Tree data converted from DIGSILENT/Power factory

In order to compare the data from DIGSILENT/Power factory and our new approach Decision Tree Algorithm, firstly, we convert the results from TABLE III into Decision Tree data format, as in Fig. 6.

In ID3 J48 Algorithm for simulation results we used WEKA machine learning software.

Based on these tools we will see that on the same terminal e.g. terminal 5, power losses Low category ($0.297=\Delta P$) for each PV Capacity. Also, we will see that in terminal 1 we will see losses of Extra High category ($\Delta P>0.414$) for each capacity of PV systems. The best case is when the PV systems are connected to terminals 3 and 4 for optimal capacity (OC) of PV systems.

From the Fig. 6 can be verified the correctness of the Decision Tree Algorithm used in this paper. In cases where the comparing of results yield a "Correct" answer, it means that the Decision Tree output is 100% correct. In cases where comparing of results yield a "Correct?" answer, it means that the training data are somehow "poor" and additional data should be taken in consideration after which probably the answer will be "Correct".

PV load and source have relatively large variations in both day and year, but it does not affect in terms of the optimization approach validity.

Decision Tree			Comparing with DIGSILENT/Power factory/ GA MATLAB Toolbox
Attributes		Classes	Classes
P_{Loss}	PV Capacity	Terminals	Terminals
EH	VLC	One	Correct
EH	LC	One	Correct
EH	MC	One	Correct
EH	OC	One	Correct?
EH	HC	One	Correct
L	VLC	Five	Correct?
L	LC	Five	Correct?
L	MC	Five	Correct
L	OC	Five	Correct?
L	HC	Five	Correct?
M	MC	Two	Correct
M	LC	Four	Correct
M	HC	Five	Correct
M	VLC	Four	Correct?
M	OC	Four	Correct?
H	MC	Three	Correct?
H	LC	Two	Correct
H	HC	Three	Correct
H	VLC	Four	Correct
H	OC	Three	Correct?

Results from DIGSILENT/Power factory/ GA MATLAB Toolbox		
Attributes		Classes
P_{Loss}	PV Capacity	Terminals
EH	VLC	One
EH	VLC	Two
EH	VLC	Three
H	VLC	Four
H	VLC	Five
EH	LC	One
H	LC	Two
H	LC	Three
M	LC	Four
M	LC	Five
EH	MC	One
M	MC	Two
M	MC	Three
M	MC	Four
L	MC	Five
EH	HC	One
EH	HC	Two
H	HC	Three
H	HC	Four
M	HC	Five

Figure 6. Comparing of results from Decision Tree and DIGSILENT/Power factory

VI. Conclusion

The impact of PV Systems on distribution networks needs to be properly evaluated and rated in order to achieve the greatest benefit for the distribution network. An optimization method based on Decision Tree Algorithm is performed in this paper to demonstrate how successfully this method could be used to determinate the optimal location of PV systems for a given capacity.

The power flow is provided by using DIGSILENT/Power Factory and optimization problem solved using GA MATLAB toolbox since it has the ability to solve nonlinear mathematical problems extremely quickly and precisely. These results are verified using Decision Tree Algorithm.

The comparison has shown that the proposed algorithm is efficient and can provide good solutions for the optimum placement of PV Systems in distribution networks. The Decision Tree Algorithm is well working and has a very good accuracy. The main challenge consists of the proper training data.

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Praise Worthy Prize

International Review of Electrical Engineering (I.R.E.E.), Vol. 12, N. 6
ISSN 1827- 6660 November – December 2017

Optimal Location and Sizing of Photovoltaic Systems in Order to Reduce Power Losses and Voltage Drops in the Distribution Grid

Armend Ymeri, Saša Mujović

Abstract – *The paper presents a method for the optimal allocation and sizing of photovoltaic systems in order to improve power quality in distribution grids. The proposed method is based on the Genetic Algorithm Matlab Toolbox application. The obtained results show that Genetic Algorithm is more accurate and convergence speed is higher than the algorithm used in DIGSILENT/Power factory software. In this way, the defined capacity and location of photovoltaic systems were checked through the performed simulations in DIGSILENT/Power factory software. The simulations were carried out with real data obtained from the Kosovo Distribution Grid. The results from the application of the proposed method showed reduced power losses and voltage drops in the distribution grid confirming the method validity.* ***Copyright © 2017 Praise Worthy PrizeS.r.l. - All rights reserved.***

Keywords: *Photovoltaic Systems, Genetic Algorithm, Power Losses, Voltage Drops, Distribution Grid*

Nomenclature

DG	Distributed generation
PV	Photovoltaic
IA	Improved analytical
HS	Harmony search
GA	Genetic algorithm
ANN	Artificial Neural Networks
DNR	Distribution network reconfiguration
IGA	Improved genetic algorithm
P_{LossL}	Power line losses without DG
r	Line resistance
L	Distance between substation and load
I_L	Line current
V_L	Load voltage
P_L	Active power line
Q_L	Reactive power line
P_G	Active power of DG
Q_G	Reactive power of DG
G	Distance between substation and DG
P_{LossSG}	Power losses from sources to the location of DG
P_{LossGL}	Power losses from the location of DG to the load
P_{LossAT}	Total line losses in the presence of DG
ΔP_{LOSS}	Line loss reduction
ΔV	Voltage drops
Z	Impedance line
R	Active resistance line
X	Inductance line
$X_{ji}(0)$	Genome of the binary value 0 or 1
O_1	Offspring
P_1	First parent
P_2	Second parent
α	Function

I. Introduction

Distributed generations (DG) are small scale electricity generations and can be defined as electric power sources directly connected to the distribution grid, whose production is not coordinated with other centralized power plants. Based on their capacity, DG can be classified into four categories:

a) Micro DG with a power capacity of 1 W – 5 kW,
b) Small DG with a power capacity of 5 kW - 5 MW,
c) Medium DG with a power capacity of 5 - 50 MW,
d) Large DG with a power capacity of 50 - 300 MW.

The main idea behind a DG is that generation is done in small scale and can be easily placed closer to the point of consumption [1]. The presence of the DG changes the load characteristics of the distribution grid. It gradually becomes an active load network and it implies changes in the power flow. A critical review of the various impacts, such as technical, economic and environmental resulting by the integration of DG in the distribution grid is presented in [2].

DG can be classified in two main groups: DG rotating systems and DG systems with inverters, part of which are photovoltaic (PV) systems and more available in the studied region. In Kosovo, the intensity of solar radiation is among the highest in Europe. Kosovo has almost 270

https://doi.org/10.15866/iree.v12i6.12553

sunny days, with energy production up to 1578 kWh/m^2 and the temperature of PV panels reaching 66°C during summer.

PV systems have played an important role in recent years due to their positive effects on the distribution grid such as: free solar energy, environmental friendliness avoiding emissions, the possibility to supply places where power systems have not been built, high reliability, easiness in use and low operating costs.

According to the Law on Energy, the power system is required to take all energy produced from PV systems. It is therefore necessary for the development of the distribution grid to predict, as accurately as possible, the impact of PV systems, so that consumers could be provided with a satisfactory electricity quality and, at the same time, strive to minimize losses. In this regard, the optimal allocation of PV systems and their sizing is pivotal and several approaches have been proposed in literature. The solution methodologies for optimal allocation are classified in three major categories: analytical, optimization programing and heuristic methods [3], [4].

The analytical method is a simple and non iterative approach which provides an approximate solution in ease of complex problems. This method is not succesful in finding solutions for real problems and, as such, it is used in rare situations. The optimal sizing of DGs were obtained using the Improved Analytieal (IA) method and Harmony Seareh (HS) algorithm but the optimal allocation of DGs was not eonsidered in [5].

Optimization programing methods are very good at providing the optimal allocation of PV systems with same/different size in a distribution grid. These methods offer better solutions eompared to analytical methods but calculation time is longer.

In [6], the digital simulation and electrical network caleulation program DIGSILENT/Power faetory is used to analyze the impact of multi DGs in terms of power losses when they are employed in the distribution grid.

When the DG is installed close to a substation, active power line losses are redueed. However, if DG's eapacity is large and is in a long distance from the substation, active power line losses tend to increase as in [7].

Artificial intelligent seareh teehniques for planning of PV systems in distribution grid may offer flexible and simplified solutions with a compromise between solution quality and computation time. Heuristic modern methods are used more in complex problems which can not be well mathematieally deseribed or can not be solved throuh exact methods. Heuristic methods usually give almost optimal solutions in cases when there is only one method, but they require high-tech efforts. The most frequently used techniques are the Genetic Algorithm (GA) and various practical heuristic algorithms. The GA offers a new and powerful approaeh to these optimization problems which are made possible by increasing the availability of high eomputers performance at relatively low cost as in [8].

Meta-heuristic methods are algorithms that add a stochastic factor to the solutions they find. Thesc algorithms are generally known as techniques that do not depend on the problem and do not take advantage of the problem particularities. In [9], there is a description of the main meta-heuristic methods implemented in the determination of the location and/or sizing of the DG.

In [10], GA using MATLAB optimization toolbox is used for determining the optimum number of DG units installed in the distribution network with optimal power losses. The best results are obtained with a combination of the three methodologies with proper ratios i.e. reconfiguration of network, installation of capacitor banks and DG units, altogether leading to a total loss reduction and, at the same time, maintaining the minimum bus voltage profile and reducing branch currents.

In [11], an algorithm for the individual allocation of DG units based on average daily power consumption and production curves is presented. The goal was the minimization of cumulative average daily active power losses. Using the proposed algorithm, the obtained DG alloeation results are more detailed and precise, which in turn can have a great importance in avoiding unnecessary and often quite considerable costs in the distribution system operator.

In [12], a new optimization method based on Artificial Neural Networks (ANN) and Genetic Algorithms (GA) is proposed for the determination of size and location of DG in radial and network distribution systems as well as for the reduction of aetive power losses and voltage profile improvement. ANNs have the ability to solve non-linear mathematical problems extremely quickly and preeisely.

In [13], a new algorithm for distribution network reconfiguration (DNR) with the simultaneous operation of DG for fault restoration on bus systems is proposed.

The proposed improved genetic algorithm (IGA) is conducted in three eases; at maximum, moderate and minimum fault eonditions in the tested system. Four DGs loeated on the testing system with optimal sizing depend from the maximum eonneeted load at the particular area.

The effeetiveness of the proposed algorithm was verified through comparing it to the conventional Genetie Algorithm and based on the analysis, the proposed algorithm gives the best solutions for fitness function and minimum eomputational time compared to the Genetic algorithm.

Influenees of DG on the losses after its connection to the distribution network is treated as a special load which can output as active power, presented in [14]. However, in the praetical application, DG eannot be simply treated as the load which can output active power.

One of the main reasons for using GA is its effeetiveness during optimization, especially in cases with a large number of parameters for various constraints. In this paper, the GA Matlab toolbox based power loss minimization and optimization technique for optimal allocation of the DGs within distribution grid for the given capacity is proposed. This approach helps in reducing the computational efforts for the selection of the appropriate location. The results obtained in this paper by using GA as a Matlab toolbox are compared to the results provided by DIGSILENT/Power factory software, in a real-time case.

The remainder of the paper is structured as follows: Problem Formulation is presented in section 2; GA implementation for optimal allocation and sizing of PV systems in distribution grid is presented in section 3; Simulation results from both methods and a comparison between them is presented in section 4; Conclusions of this paper are summarized in section 5 and, finally, Future Works are summarized in section 6.

II. The Problem Formulation

The main goal of this paper is to study the optimal allocation and sizing of PV systems in order to reduce active power losses and voltage drops in the distribution grid. Active power losses exist at all levels of power systems such as generation, transmission and distribution systems. Most of them occur in the distribution systems because of the low voltage, high current levels and radial configuration of these systems.

II.1. Power Losses Analysis without DG

Power line losses occur when current flows through the distribution grid and they depend on the current amount and resistance. Referring to literature as in [9], [10], the mathematical model for the calculation of power line losses for the case without DG in the distribution line can be calculated by equation (1):

$$P_{LossL} = 3I_L^2 r L \tag{1}$$

Losses for a three-phase system without DGs can be expressed as in (2):

$$P_{LossL} = \frac{r L\left(P_L^2 + Q_L^2\right)}{3V_L^2} \tag{2}$$

Here, P_{LossL} are power line losses without DGs, r is line resistance (Ω/km), L is the distance between substation and load, I_L is line current (A).

II.2. Power Losses Analysis with DG

When DG is connected in the distribution grid, power losses are calculated by a combination of power line losses from the source to the DG and power losses from the location of DG to the load location, as in (3) and (4):

$$P_{LossSG} = \frac{rG}{3V_L^2}\left(P_L^2 + Q_L^2 + P_G^2 + Q_G^2 + \right.$$
$$\left. -2P_L P_G - 2Q_L Q_G\right) \tag{3}$$

$$P_{LossGL} = \frac{r\left(P_L^2 + Q_L^2\right)}{3V_L^2}(L-G) \tag{4}$$

Here, P_{LossSG} are power losses from the sources to the location of DG, P_{LossGL} are power losses from the location of DG to the load.

The total line loss (P_{LossAT}) in presence of DG can be calculated by combining equations (2) and (3) and are expressed as in (5):

$$P_{LossAT} = \frac{rL}{3V_L^2}\left[\left(P_L^2 + Q_L^2\right) + P_G^2 + Q_G^2 + \right.$$
$$\left. -2P_L P_G - 2Q_L Q_G\left(\frac{G}{L}\right)\right] \tag{5}$$

Here, P_L is active power line, P_G is active power of DG, Q_L is reactive power line, Q_G is reactive power of DG, V_L is load voltage, and G is the distance between the substation and the DG.

Loss reduction or instantaneous loss savings ΔP_{LOSS} at any point on a feeder can be represented as the difference between losses without DG and losses with DG as in (6) and they can be positive or negative:

$$\Delta P_{LOSS} = P_{LossL} - P_{LossAT} \tag{6}$$

$$\Delta P_{LOSS} = \frac{rG}{3V_L^2 L}\left(P_G^2 + Q_G^2 - 2P_L P_G - 2Q_L Q_G\right) \tag{7}$$

The difference between the loss with DG and without DG gives the losses reduction ΔP_{LOSS}.

When the loss in the system is reduced, then ΔP_{LOSS} has the positive sign and, if not, it is indicated with the negative sign.

It indicates that DG causes the system loss to increase [15], [16].

If the location and installed power of the DG are chosen to fit the size and location of the load, it will help to reduce power losses in the line.

II.3. Voltage Drops Analysis

During the calculation of voltage drops in the distribution grid, the ratio X/R must be taken into account, because, in the distribution grid, active resistance cannot be ignored.

In this way, it is possible to model the distribution lines with impedance $Z=R+jX$ and voltage drops as in (8):

$$\Delta V = \frac{P_L R + Q_L X}{V_L} \tag{8}$$

The above equations should be considered as one of the constraints of the optimization problem [17].

III. GA Implementation for Optimal Allocation and Sizing of PV Systems

GA is a heuristic-stochastic method used to search solutions by means of genetic heritage and Darwin theory. GA belongs to a class of heuristic optimization methods that mimic the natural processes of evolution, the so-called Evolutionary Algorithms (EA). Their common characteristic is that they generate solutions to optimization problems using techniques inspired by the biological evolution, such as: initialization, evaluation, selection, crossover and mutation. In this paper, the authors performed GA using an optimization tool in Matlab with its default criteria through the following steps:

- *Initialization*: In this step, the generation of random chromosomes for the DG is performed as in (9):

$$X_j(0)=\left[X_{j1}(0),X_{j2}(0),\ldots,X_{jm}(0)\right] \quad (9)$$

$X_{jk}(0)$ is generated in search space $\left(X_k^{min},X_k^{max}\right)$ randomly.

Here, $X_{jl}(0)$ is a genome of the binary value 0 or 1.

Due to the fact that the values of inputs used in this problem are of double data type, the most apropriate criteria for population initialization is the double vector method.

- *Evaluation*: in this step, for each chromosome in the initial population the value is calculated based on a specific objective function. This objective function in the proposed approach is derived from formulas in section 2.

Finally, the best value is picked as the fitness value:

$$F(chromosomes) \Rightarrow bestchromosome$$

- *Selection*: In this step, a selection of potential useful solutions for recombination is done through stochastic universal sampling using two different chromosomes as parent chromosomes and comparing them to the other method of selection, known as roulette wheel selection, which has a better time complexity O (*N*) than roulette wheel selection has O (*N* log *N*).
- *Crossover*: In this step, by using the chromosomes from step 3, a new child having some parts of both parent's genetic material was created. Where there is a linear constraint, an intermediate method was chosen.

This choice ensures that feasible parents give rise to feasible children. This process is done using this rule.

$$O_1 = P_1\alpha\left(P_2 - P_1\right) \quad (10)$$

Here, O_1 is offspring, P_1 is the First parent, P_2 is the second parent, α is the function.

- *Mutation*: In this step, mutation seeks to improve chromosomes by flipping the specific genes of these chromosomes. Mutation is performed using the Gaussian method which adds a random number to each vector entry of an individual chromosome. This random number is taken from a Gaussian distribution centered in zero.

The next step to determine the correct solution for minimizing active power losses is to choose the appropriate location and size of PV systems for implementation. This is done by using the above explained GA (see Fig. 1).

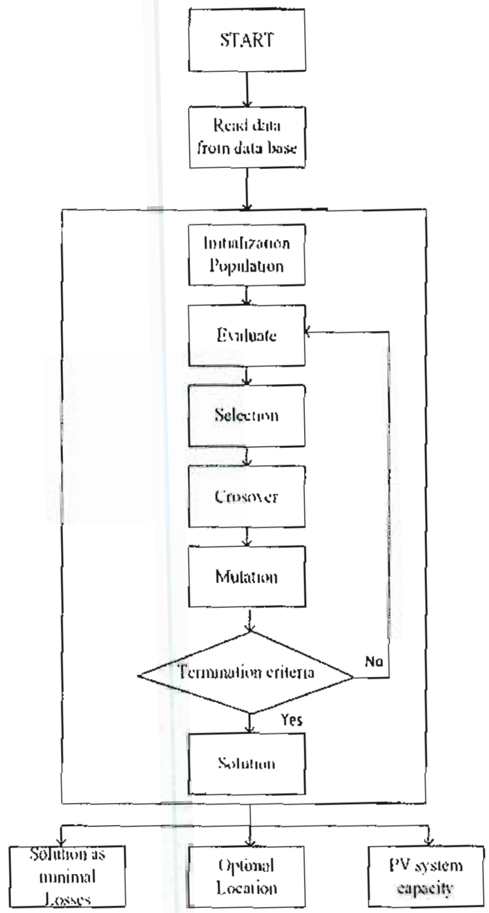

Fig. 1. Flowchart of the GA

III.1. Application of the GA on Real Distribution Grid

In order to achieve the best location of PV systems in the distribution grid and to minimize the active power losses in 10 kV line, the GA is applied on a part of distribution grid of KEDS (Kosovo Electricity Distribution and Supply), as presented in Table I.

TABLE I
DATA OF 10 kV LINE "MUÇIVERÇ"

Terminal (Bus bar)	Distance (km)	Load (MW)
1	3.35	0.012
2	4.62	0.198
3	1.7	0.503
4	6.36	0.775
5	9.99	1.076

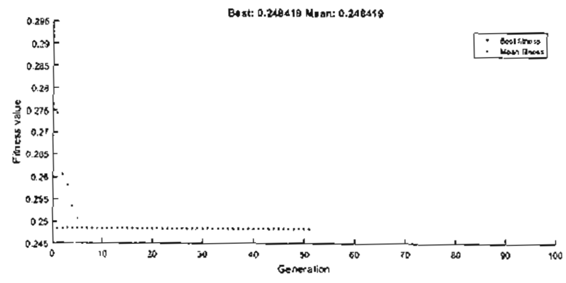

Fig. 2. Best optimum of active power losses provided by GA

GA Matlab Toolbox has reached a stable (optimum) solution with 50 iterations (see Fig. 2). According to the outputs, the optimal location for a PV system is node (terminal) 5, while the values for the corresponding size and total power losses for the given load are 2.564 MW and 0.248419 MW, respectively. The corresponding detailed outputs are given in Table II.

TABLE II
GA OUTPUTS

Best Placement	Terminal
PV system capacity (MW)	2.564
Active Power Losses (MW)	0.248

In order to verify the optimal size at the above location, numerous load flow simulations were carried out with different sizes of PV systems, starting from 0.4 to 4 MW.

The surface diagram of the results obtained through GA is shown in Fig. 3.

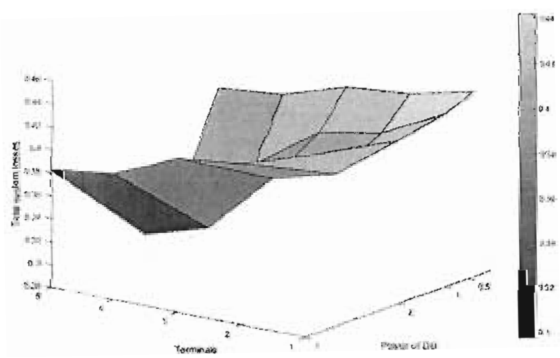

Fig. 3 Surface diagram generated using GA results

The dark blue area represents a set of optimal solutions according to the optimization formulation defined earlier in this paper.

The power of PV systems from 2 MW to 2.564 MW causes the lowest level of the total active power losses in the analyzed system and it is the best result of PV systems placement. This indicates the result with the lowest system losses of 0.248419 MW located at terminal 5, at the end of the distribution feeder.

Moreover, another interesting observation can be derived from Figure 3. It is noticed that when the PV systems size exceeds 4 MW, total line losses increase more than losses in case of a PV systems capacity of 1 MW and 2 MW.

Blue color in the scale of the axis presents lower losses from 0.297433 MW to 0.368346 MW for a PV system capacity between 2 MW and 4 MW.

The green color presents losses from 0.368346 MW to 0.393725 MW for a PV system capacity between 1 MW and 2 MW. While the yellow color in the scale of the axis presents the biggest losses from 0.401437 MW to 0.442034 MW for a PV system capacity of 0.4 MW.

IV. Simulation Results

GA and DIGSILENT/Power factory use the same database. By running GA on a set of variables for a selected terminal and by running the power flow calculation in DIGSILENT/Power factory software with the same PV systems values, the results can be compared and evaluated. The performance of the GA is acceptable; the comparison of the results given by DIGSILENT/Power factory and those by GA show that GA manages to determine the valid value of active power losses. The results of GA generally match the results provided by DIGSILENT/Power factory. The DIGSILENT/Power factory software results are calculated for each terminal (busbar) with different PV systems capacities (from 0.4 MW to 4 MW).

DIGSILENT/Power factory is a method for the reconfiguration of the radial distribution grid, which is considered a modern method of optimization of locations which determines the capacity of PV systems. This program is capable of calculating load flow, short-circuit level, active and reactive losses of the grid and the parameters of the grid. This software is expensive, not available for free research and is developed and maintained by DIGSILENT GmbH [18].

IV.1. Case without PV Systems

The total peak power demand in 10 kV line "Muçivere" is 2.564 MVA. Based on the simulation carried out during September 2013, the results of power line losses in the case without PV systems are ΔP=0.4514MW as shown in Table III.

TABLE III
POWER LOSSES WITHOUT PV SYSTEMS IN TERMINALS OF 10 kV LINE

Terminal (Bus bar)	Power Losses (MW)
1	0.00000089
2	0.005515
3	0.010774
4	0.101000
5	0.334062
Total:	0.4513627

IV.2. Case with PV Systems

A PV system is used for the purpose of modelling and testing the proposed method. The installation capacity of

PV systems can vary from 0.4 MW to 4 MW and can be connected to 5 terminals of 10 kV line with length L = 26.02 km (see Fig. 5).

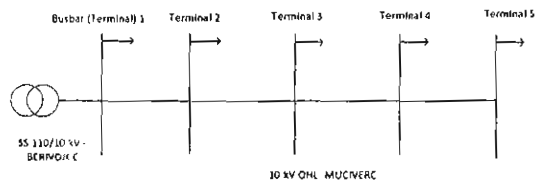

Fig. 4. Single line diagram of 10 kV line without PV systems

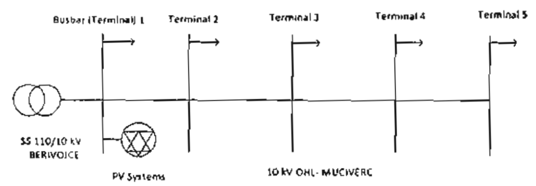

Fig. 5. Single line diagram of 10 kV line with PV in first terminal

By changing the location of the PV systems but keeping the same size, in three cases (0.4 MW, 1 MW and 2 MW and 4 MW), active power line losses in all terminals are smaller than in the case without PV systems. Accordingly, the distribution grid has benefits from the installation of PV systems. If PV systems are in the second half of the distribution line, power losses are smaller than in the case without PV systems. This means that, if PV systems are installed near the consuming center, it can cause reductions of the total power losses.

Table IV shows that, when the capacity of PV systems is between 1 MW and 2 MW and the location between terminals 3 and 4, power losses are smaller than in the case without PV systems.

TABLE IV
POWER LOSSES WITH PV SYSTEMS IN 10 kV LINE

Power Losses (MW)		PV Systems capacity		
Terminal (Bus bar)	0.4 (MW)	1 (MW)	2 (MW)	4 (MW)
1	0.442034	0.431395	0.422603	0.438544
2	0.429170	0.403858	0.382940	0.420866
3	0.424436	0.393725	0.368346	0.414361
4	0.406727	0.355817	0.313745	0.390024
5	0.401437	0.344492	0.297433	0.382754

Based on further analysis on the same terminal, it can be seen that if the size of PV system is 2 MW and is under P_{max}, power losses are lower than in the cases with the capacity of 4 MW and 0.4 MW. The best case is when the PV systems are connected to terminal 4.

However, when the capacity of the PV systems exceeds the load line (4 MW) and the distance between them and the substation is not long, in this case power losses will increase.

The results obtained from these two implemented methods show that GA Matlab Toolbox is more robust in terms of PV systems capacity. GA Matlab Toolbox provided the result where the capacity of PV systems was 2.564 MW and losses were 0.248 MW. Compared to DIGSILENT/Power factory software, the results of losses was 0.297433 MW for a PV system capacity of 2 MW in terminal 5. In general, the results obtained from GA Matlab Toolbox are more positive and more comprehensive than the results obtained from DIGSILENT/Power factory software.

The total active power losses before installing PV systems in the distribution system were 0.4514 MW; after implementing the PV systems on the designated terminal, the total system losses were 0.248 MW or 45.096% lower. A significant improvement in the voltage profile, as an additional advantage of optimal PV systems allocation, has also been observed and demonstrated by the results of DIGSILENT/Power factory software calculation. Voltage drops in the radial distribution grid in the case without PV systems are increased when being far from the substation and they are in a critical point of 32.045%. However, this depends on the level of load (consumption) in the grid. Voltage drops are much smaller in eases when PV systems are connected with different capacities and locations.

When PV systems are located in the fourth terminal and with their capacity of 4 MW (more than P_{max} of this line), the critical point of the grid will be terminal 4, as shown in Table V. From this table, the voltage drops in the case without PV system in the critical point are 32.045% and in the case with PV systems they are 0.046%, which are negligible.

Voltage drops with PV systems with 0.4 MW capacity are 22.06%, which are under the allowed maximum voltage drop range as for the IEC 61000 standard applied to distribution networks, which is ±10% to ±15% [19].

Anyway, with the increase of the PV systems capacity, it will be smaller.

TABLE V
VOLTAGE DROPS IN 10 kV LINE IN CRITICAL POINT

Voltage Drops		PV Systems capacity			
Terminal (Bus bar)	Without PV	0.4 (MW)	1 (MW)	2 (MW)	4 (MW)
1		30.844	28.873	25.159	34.425
2		29.373	25.121	17.473	19.239
3		28.697	23.469	14.290	23.026
4		26.155	17.581	3.648	0.046
5	32.045	22.373	12.282	3.179	0.078

V. Conclusion

PV systems are increasingly common in the electrical distribution grid. The impact on distribution grids needs to be properly evaluated and rated in order to achieve the greatest benefit for PV systems as well as for the distribution grid. An optimization method based on GA Matlab Toolbox is performed in this paper to demonstrate how successfully this method could be used to determinate the size and location of PV systems. At the same time, this method is used to demonstrate the reduction of active power losses and voltage drops. The correct solution for solving the given formulation is provided by using GA, since it has the ability to solve nonlinear mathematical problems extremely quickly and precisely. Those results are verified using DIGSILENT/Power factory software. GA finds the best location of PV systems and the smallest value of power losses 0.248 MW whereas DIGSILENT/Power factory software offers results for only predefined capacity of PV systems.

This study shows that the proper allocation and sizing of PV systems can have a significant impact on system loss reduction. But it also depends on the size of load terminals and of PV systems. However, if the size is further increased, losses start to increase as well. A conclusion that rises from this study is that PV systems' size should only reach a capacity that can be consumed within the distribution substation boundary.

Also, voltage drops in the critical point are much smaller in cases where PV systems are connected.

VI. Future Works

Basically, the grid integration of PV systems is a very complex issue, thereby it is important to consider the benefits of PV systems, e.g. reduction of grid power losses and voltage drops. Therefore, the optimal allocation of PV systems with minimum losses is very important. The integration of Fuzzy logic with Artificial Neural Network is a major area of research as it combines the advantage of both these fields. Hybrid approaches, like a combination of Artificial Neural Network (ANN) with other techniques like Fuzzy Logic (FL) and GA, are promising areas which are being investigated for more accurate and optimized use of power systems with minimum losses.

Furthermore, the new methods based on Hypergraph decomposition can be very promising for the optimal allocation and sizing of PV systems.

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Armend Ymeri je rođen 1971. godine u Gnjilanu, Kosovo. Osnovnu i srednju školu je završio u Gnjilanu, a redovne studije na Elektrotehničkom fakultetu u Prištini, smjer Elektroenergetski sistemi, na kojem je diplomirao 1997. godine. Tema diplomskog rada je bila "Električne instalacije velikih potrošača posebnih karakteristika".

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- Upravljanje sektorom za održavanje mreže u naponskim nivoima 35 kV, 10 kV i 0,4 kV za celo Kosovo.
- Održavanje i razvoj vodova 35 kV, 10 kV i 0,4 kV kao i trafostanica 35/10 kV, 10 / 0,4 kV u Elektrodistribuciji Gnjilana
- Analiza i proračun tehničkih gubitaka i priprema 10 kV jednopolnih šema
- Priprema tenderske dokumentacije i izvodljivosti tehničkih specifikacija
- Izrada elektroenergetskih saglasnosti i odobrenja za priključenja novih trafostanica TS 10(20)/0,4 kV i novih distrbutivnih 10 kV i 0,4 kV vodova
- Projektovanje elektroenergetskih projekata za nove trafostanice 10(20)/0,4 kV i novih distributivnih 10 kV i 0,4 kV vodova

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Informatička znanja:
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Dosadašnji naučno-istraživački rad prof. dr Saše Mujovića je rezultirao objavljivanjem većeg broja radova u međunarodnim i domaćim časopisima, kao i prezentacijama na međunarodnim i domaćim naučnim skupovima. Recezent je u više uglednih međunarodnih časopisa.

Do sada je pod mentorstvom prof. dr Saše Mujovića doktorirao jedan kandidat, magistrirala su četri kandidata, a njih 49 je odbranilo specijalističke radove.

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2. Iličković, S., **Mujović, S**., Radović, J. (2012) A Case Study Survey of the Impact of the Inductive Loads on Power Quality. *Journal of Energy and Power Engineering*, 6 (10): 1698-1705. ISSN: 2326 - 960X.
3. **Mujović, S**., Đukanović, S. (2013) Utvrđivanje karakteristika i modelovanje faktora ukupne harmonijske distorzije struje grupisanih računara. *Bosanskohercegovačka elektrotehnika*, 7: 37-42. ISSN: 1512-5483.
4. Božović, M. **Mujović, S** (2014) Application of Contemporary Data Acquision System for Power Quality Control on Examle of Ironwork Plant Niksic. *ETF Journal of Electrical Engineering*, 20: 5-19. ISSN: 0353-5207.
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3.**Mujović, S**., Đukanović, S. (2013) "Development of Mathematical Models for Current and Voltage Harmonic Distortion due to PC Group Operation. Proceedings of the Symposium , 17th International Symposium on Power Electronics – Ee 2013, Novi Sad, Oct. 30th - Nov. 1st 2013, Paper No. T.6.10, pp. 1-5.

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5. Vujošević, S., **Mujović, S**., (2017) Application of EMD and STFT Methods in Analysis of Energization of an Unloaded Overhead Line Under Different Operating Conditions. Internalional Symposium on Power Quality ISPQ 2017, Teslić, BiH.

6. Drinčić, F., **Mujović, S**., (2018). Energy storage systems: An overview of existing technologies and analysis of their application within the power system of Montenegro. IT 2018, Žabljak.

e) Projekti čiji je rukovodilac Prof. dr Saša Mujović

1. Distributed generators – the ekological solution for electricity generation and development opportunity, Bilateral project with the Faculty of Electrical Enginering Tuzla (2014-2016).

2. Development and optimization of infrastructure for electric and hybrid vehicles power supply in urban and touristic areas of Serbia and Montenegro, Bilateral project with the Faculty of Technical Science Novi Sad (2016-2018).

3. Research of possibilities of the modern power systems and the role of electrical and hybrid vehicles in them with a focus on cities in Serbia and Montenegro, Bilateral project with the Faculty of Technical Science Novi Sad (2019-2021).

4. Cross border management of variable renewable energies and storage units enabling a transnational wholesale market – CROSSBOW, HORIZONT 2020 Project (2018-2022).

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O D L U K U
O IZBORU U ZVANJE

Dr Saša Mujović bira se u akademsko zvanje **vanredni profesor Univerziteta Crne Gore** za predmete **Ispitivanje električnih mašina, Eksploatacija i planiranje EES, Projektovanje pomoću računara u EES i Modelovanje i dinamika električnih mašina** na akademskom specijalističkom studijskom programu Energetika i automatika na Elektrotehničkom fakultetu, na period od pet godina.

REKTOR
Prof. Radmila Vojvodić

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Primljeno: 07. 11. 2016			
Org. jed.	Broj	Prilog	Vrijednost
02/1	2081		

Prof. dr Vladan Vujičić
Elektrotehnički fakultet
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KRATKA BIOGRAFIJA

Vladan Vujičić rođen je 30.08.1968. godine u Titogradu (Podgorica), gdje je završio osnovnu i srednju školu.

Diplomirao je na Elektrotehničkom fakultetu u Podgorici 05.02.1993. godine. Magistarski rad pod nazivom: "Upravljanje grejderskim uređajem po zadatoj putanji" odbranio je na istom fakultetu 29.12.1995. godine. Doktorsku disertaciju pod nazivom: "Proširenje eksploatacione karakteristike pogona sa prekidačkim reluktantnim motorom primjenom nesimetrične konfiguracije motora i pogonskog pretvarača", odbranio je 01.03.2001. godine na Elektrotehničkom fakultetu u Beogradu.

Od 01.04.1993. godine radi na Elektrotehničkom fakultetu u Podgorici. Do 1996. godine radio je kao saradnik, a u periodu od 1996. do 2002. godine kao asistent na Katedri za teorijsku i primijenjenu automatiku. U zvanje docenta izabran je u junu 2002. godine, a u zvanje vanrednog profesora u julu 2007. godine. Krajem juna 2012. godine izabran je u zvanje rednovnog profesora Univerziteta Crne Gore za predmete: Energetska elektronika, Projektovanje energetskih poluprovodničkih pretvarača, Mehatronika i Specijalne električne mašine.

U junu 2001. godine boravio je na Katoličkom univerzitetu u Luvenu, kao dobitnik stipendije udruženja evropskih Univerziteta ("COIMBRA Group"). Na kraćim boravcima, u okviru realizacije međunaronih i bilateralnih projekata, bio je na Univerzitetu u Ljubljani (januar 2004. godine), Univerzitetu La Sapienza u Rimu (jun 2006. godine) i Univerzitetu rudarstva i tehnologije u Kini (Xuzhou, decembar 2015. godine).

U periodu od 2002. do 2004. godine obavljao je funkciju šefa Katedre za teorijsku i primijenjenu automatiku. Od juna 2011. godine predsjednik je Studijskog komiteta B4 – Jednosmjerni sistemi i energetska elektronika – Crnogorskog Komiteta Međunarodnog vijeća za velike električne mreže (CG KO CIGRE).

Objavio je preko sedamdeset naučnih radova u međunarodnim i domaćim časopisima, kao i na međunarodnim i domaćim konferencijama. Kao autor ili koautor objavio je tri udžbenika i desetak skripti koje se koriste u nastavi. Učestvovao je u izradi devet domaćih i međunarodnih naučno-istraživačkih i stručnih projekata. Za projekat realizovan u periodu 2005. do 2007. godine dobitnik je posebnog priznanja (*Certificate of excellence - Best content*) od strane WUS-Austria. Recenzent je u nekoliko međunarodnih časopisa iz edicije IEEE i IET. Pod njegovim mentorstvom odbranjene su dvije doktorske disertacije, tri magistarske teze i veliki broj diplomskih i specijalističkih radova.

Član je Međunarodnog udruženja inženjera elektrotehnike (Institute of Electrical and Electronics Engineers - IEEE) i Međunarodnog vijeća za velike električne mreže (Conseil International des Grands Réseaux Electriques - CIGRE).

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DESET NAJZNAČAJNIJIH NAUČNO-ISTRAŽIVAČKIH RADOVA

1. M. P. Ćalasan, **V. P. Vujičić**, "Sensorless control of wind SRG in dc microgrid application", *International Journal of Electrical Power & Energy Systems*, vol. 99, pp. 672–681, July 2018. (ISSN: 0142-0615, 2017 *JCR Impact Factor*: 3.610, https://doi.org/10.1016/j.ijepes.2018.02.014)
2. M. P. Ćalasan, **V. P. Vujičić**, "A robust Continuous Conduction Mode control strategy of Switched Reluctance Generator for wind power plant applications,"*Archiv für Elektrotechnik - Electrical Engineering*, vol. 99, no. 3, pp.943-958, Sep. 2017. (ISSN: 0948-7921, 2017 *JCR Impact Factor*: 1.269, DOI: 10.1007/s00202-016-0459-1)
3. M. P. Ćalasan, **V. P. Vujičić**, "SRG Converter Topologies for continuous conduction operation: A Comparative Evaluation," *IET Electric Power Applications*, vol. 11, no. 6, pp. 1032-1042, July 2017. (ISSN 1751-8660, 2017 *JCR Impact Factor*: 2.211, DOI: 10.1049/iet-epa.2016.0659)
4. **V. P. Vujičić**, M. P. Ćalasan, "Simple Sensorless Control for high-speed Operation of Switched Reluctance Generator,"*IEEE Transactions on Energy Conversion*, vol. 31, no 4., pp. 1325-1335, Dec. 2016. (ISSN 0885-8969, 2016 *JCR Impact Factor*: 3.808, DOI: 10.1109/TEC.2016.2571841)
5. **V. P. Vujičić**, "Minimization of Torque Ripple and Copper Losses in Switched Reluctance Drive," *IEEE Transactions on Power Electronics*, vol. 27, no. 1, pp. 388-399, Jan. 2012. (ISSN 0885-8993, 2012 *JCR Impact Factor*: 4.08)
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7. **V. P. Vujičić**, S. N. Vukosavić, and M. Jovanović: "Asymmetrical Switched Reluctance Motor for a Wide Constant Power Range," *IEEE Transactions on Energy Conversion*, vol. 21, no.1, pp. 44-51, March 2006. (ISSN 0885-8969, 2006 *JCR Impact Factor*: 0.716)
8. **V. Vujičić**: "Torque Ripple and Output Power Characteristics of the Asymmetrical Switched Reluctance Drive," *WSEAS Transactions on Systems*, Issue 9, Vol. 4, pp. 1474-1481, September 2005. (ISSN: 1109-2777)
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Na osnovu člana 75 stav 2 Zakona o visokom obrazovanju (Sl.list RCG, br. 60/03 i Sl.list CG, br. 45/10 i 47/11) i člana 18 stav 1 tačka 3 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 28.06.2012. godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr VLADAN VUJIČIĆ bira se u akademsko zvanje **redovni profesor** Univerziteta Crne Gore za predmete: Energetska elektronika, akademske studije, studijski program EA, Projektovanje energetskih poluprovodičkih pretvarača, specijalističke akademske studije, strudijski program EA, Specijalne električne mašine, specijalističke akademske studije, studijski program EA i Mehatronika, specijalističke akademske studije, studijski program EA**, na Elektrotehničkom fakultetu.**

R E K T O R
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Radulović Vladan je rođen 27.08.1979. godine u Podgorici. Na Elektrotehnički fakultet u Podgorici, odsjek energetika, upisao se 1998. godine. Diplomirao je 01.11.2002. godine odbranom diplomskog rada "Sklopni prenaponi" sa ocjenom 10 i prosječnom ocjenom tokom studija 9,79..

Na poslijediplomske studije na Elektrotehničkom fakultetu u Podgorici, smjer elektroenergetski sistemi, upisao se 2002. godine i iste završio sa prosječnom ocjenom 10. Magistarsku tezu pod nazivom „Izbor odvodnika prenapona sa aspekta uticaja privremenih prenapona u elektroenergetskom sistemu" je odbranio 06.06.2005. godine na Elektrotehničkom fakultetu u Podgorici.

Doktorsku disertaciju pod nazivom: „Optimizacija sistema zaštite od atmosferskog pražnjenja u električnim instalacijama niskog napona" odbranio je 08.03.2011. godine na Elektrotehničkom fakultetu u Podgorici.

U zvanje docenta na Elektrotehničkom fakultetu izabran je u novembru 2011. godine, a u zvanje vanrednog profesora u januaru 2017 godine.

Autor je više naučnih i stručnih radova u renomiranim međunarodnim i domaćim časopisima i konferencijama. Član je više međunarodnih i domaćih organizacija i udruženja. Recenzent je u više renomiranih međunarodnih časopisa.

Oblasti stručnog interesovanja su: elektrane, alternativni izvori električne energije, prenaponska zaštita, tehnika visokog napona, visokonaponska razvodna postrojenja, modelovanje elemenata elektroenergetskih sistema.

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Izvod iz bibliografije - Spisak najznačajnih referenci

1. **V. Radulović**, S. Škuletić (2011): „Influence of Combination Wave Generator's Current Undershoot on Overvoltage Protective Characteristics", IEEE Transactions on Power Delivery, 2011, Vol. 26, Issue 1, pp. 152–160, ISSN: 0885-8977, DOI: 10.1109/TPWRD.2010.2060501

2. Katić V., Mujović S., **Radulović V.**, Radović J (2011).: „The Impact of the Load Side Parameters on PC Cluster's Harmonics Emission", Advances in Electrical and Computer Engineering, 2011, Vol. 11, Broj 1, pp. 103-110, ISSN 1582-7445, DOI: 10.4316/AECE.2011.01017

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4. **Radulović V.**, Mujović S., Miljanić Z. (2015): "Characteristics of Overvoltage Protection with Cascade Application of Surge Protective Devices in Low-Voltage AC Power Circuits", Advances in Electrical and Computer Engineering, 2015, Vol. 15, Issue 3: 153-160, ISSN 1582-7445, DOI: 10.4316/AECE.2015.03022

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6. **Radulović V.**, Miljanić Z. (2016): "The Requirements for Efficient Overvoltage Protection of Electronic Devices in Low-Voltage Power Systems". Tehnički vjesnik Technical Gazette Vol. 24, No. 6, pp. 1813-1819, 2017DOI: 10.17559/TV-20160128145656

7. **V. Radulović**, S. Mujović , Z. Miljanić (2017): „Effects of Different Combination Wave Generator Design on Surge Protective Devices Characteristics in Cascade Protection Systems", IEEE Transactions on Electromagnetic Compatibility, Vol. 59, Issue 3, pp. 823 – 834, 2017 DOI: 10.1109/TEMC.2016.2632752

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O D L U K U
O IZBORU U ZVANJE

Dr Vladan Radulović bira se u akademsko zvanje **vanredni profesor Univerziteta Crne Gore** za oblast **Elektroenergetika na Elektrotehničkom fakultetu,** na period od pet godina.

REKTOR

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BIOGRAFIJA

Vesna Popović-Bugarin je rođena 03. 05. 1978. godine u Podgorici. Osnovnu i srednju školu (Gimnazija "Slobodan Škerović", prirodno-matematički smjer) završila je u Podgorici. U toku školovanja učestvovala je i osvajala nagrade na opštinskim i republičkim takmičenjima u znanju iz fizike. Diplomirala je, magistrirala i doktorirala 2001, 2005. i 2009. godine, respektivno, na Elektrotehničkom fakultetu (ETF) u Podgorici.

Elektrotehnički fakultet u Podgorici je upisala 1996. godine na odsjeku Elektronika, gdje je i diplomirala 2001. godine, odbranivši diplomski rad pod nazivom "**Primjena vremensko-frekvencijske analize signala u neonatologiji**".

Postdiplomske studije, smjer Računari, upisala je školske 2002. godine na Elektrotehničkom fakultetu u Podgorici. Magistrirala je 30. 06. 2005. godine, odbranivši magistarsku tezu pod nazivom "**Spektralna analiza nestacionarnih signala metodama sa visokom rezolucijom**". Tokom postdiplomskih studija boravila je u Ženevi, Švajcarska, na institutu za nuklearna istraživanja – CERN (European Organisation for Nuclear Research), u periodu od 08. 06. 2004. do 18. 07. 2004. godine.

Doktorsku disertaciju "**Vremensko-frekvencijska analiza u obradi radarskih signala**", pod mentorstvom prof. dr Ljubiše Stanković, odbranila je 29. 06. 2009. godine. Tokom doktorskih studija boravila je u: Brestu, Francuska, na ENSIETA-i (École Nationale Supérieure d'Ingénieurs), u periodu od 24. 05. 2006. do 24. 06. 2006., kao i u Bonu, Njemačka, na Univerzitetu primijenjenih nauka, Bonn-Rhein-Sieg University of Applied Sciences, u periodu od 02. 08. 2007. do 02. 09. 2007.

Član je profesionalnih udruženja: Institute of Electrical and Electronics Engineers (IEEE), IEEE Signal Processing Society, Odbora za informaciono-komunikacione tehnologije pri CANU i Centra za mlade naučnike pri CANU.

Vesna Popović-Bugarin je zaposlena na ETF-u od 2002. godine, 27.05.2010. godine je izabrana u zvanju docenta, dok je 24.06.2015. izabrana u zvanje vanrednog profesora.

Oblasti njenog interesovanja uključuju vremensko-frekvencijsku analizu signala, obradu radarskih signala, analizu mikro-Doppler efekta u radarskim signalima i vještačku inteligenciju.

Vesna Popović-Bugarin je bila angažovana na velikom broju domaćih i međunarodnih naučnih projekata, kao i na dva FP7 projekta. Objavila je 35 naučnih radova, od čega 11 u međunarodnim časopisima sa SCI liste. Koautor je jednog domaćeg udžbenika i po jednog poglavlja u dvijema monografijama izdatim od strane inostranih izdavača.

Vesna Popović-Bugarin je obavljala funkciju zamjenika naučnog direktora BIO-ICT Centra izvrsnosti.

Više detalja i kompletan spisak referenci može se pronaći na sajtu www.tfsa.ac.me.

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Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju (Službeni list Crne Gore br. 44/14) i člana 32 stav 1 tačka 9 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 24. juna 2015. godine, donio je

ODLUKU
O IZBORU U ZVANJE

Dr VESNA POPOVIĆ-BUGARIN bira se u akademsko zvanje **vanredni profesor Univerziteta Crne Gore** za predmete: Osnovi računarstva II na osnovnom akademskom studijskom programu Elektronika, telekomunikacije i računari, Baze podataka i Ekspertni sistemi na postdiplomskom specijalističkom akademskom studijskom programu Elektronika, telekomunikacije i računari, **na Elektrotehničkom fakultetu**, na period od pet godina.

REKTOR

Prof. Radmila Vojvodić

УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
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Број 02/1-1169
Подгорица, 29. 06. 2015 год.

CV
Dr. sci. Samir Avdakovic, dipl. ing. el.

Dr. Samir AVDAKOVIC was born in 1974 in Doboj, Bosnia and Herzegovina. He received his M.Sc. and Ph.D. degree in electrical engineering at the Faculty of Electrical Engineering, University of Tuzla in 2006 and 2012, respectively. Currently, he is working in the Department for Strategic Development in EPC Elektroprivreda B&H and Faculty of electrical engineering - Department of Power Engineering - University of Sarajevo. Since October 2014, he has been an Assistant Professor at the Faculty of Electrical Engineering, University of Sarajevo, where he currently teaches courses in fundamentals of Power System Operations and Control and Power System Planning. His research interests are: power system analysis, power system dynamics and stability, WAMPCS, smart systems, signal processing, biomedical engineering. He is married and father two children, Amar and Tajra.

PERSONAL INFORMATION:

Title, degree – Ph.D., Mr.Sci., electrical engineer
Citizenship - Bosnia and Herzegovina
Gender - Male
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Date of birth: 12.11.1974.

WORK EXPERIENCE:

2001-2002: Teacher of mathematics and a group of electrical items at two high schools, i.e. High school Doboj-Istok and High school Bihac.

2002- : EPC Elektroprivreda B&H d.d. Sarajevo, Department for development – Senior expert for power distribution system development

2014-: University of Sarajevo, Faculty of electrical engineering - Department of Power Engineering – Ph.D. – Assistant Professor

Work experience in Public Utility Elektroprivreda B&H Sarajevo, in Department for strategic development includes:

- ✓ Energy and power demand analyses;
- ✓ Energy and power demand forecasting (long-term and short-term);
- ✓ Power system modeling and analyses (power flow, fault analysis, transient stability, voltage stability, etc.)
- ✓ Power distribution modeling and analyses (power flow, fault analysis, integration of distributed generators into real distribution system, integration of electric vehicles into distribution system, etc.)
- ✓ Data analyses
- ✓ Signal analyses using advance signal processing techniques

- ✓ Energy efficiency in power distribution systems.
- ✓ Pilot projects and testing different metering devices and systems (AMR/AMM, Power Quality, metering devices, etc.)
- ✓ Study research – several study research in area of power distribution system;
- ✓ Work with consulting company on different study research (HPP, TPP and WPP connection study, SCADA systems, AMR/AMM systems, etc..).

Work experience at Faculty of electrical engineering - University of Sarajevo includes courses in fundamentals of Power System Operations and Control and Power System Planning, mentorships for several PhD candidates and MSc candidates, and continuously work projects for the industry.

LANGUAGE

Bosnian/Croatian/Serbian (native)
English (Conversational)
Russian (understand)
Can work with Cyrillic script

PARTICIPATION IN SPECIALIST ORGANISATIONS OVER THE PAST FIVE YEARS

- ✓ The Bosnian-Herzegovinian American Academy of Arts and Sciences (BHAAAS) – Associate member and Head of Technical section;
- ✓ CIGRE Paris – Member;
- ✓ CIGRE – BHK – member and President of C2 – Power System Operation and Control;
- ✓ DEVELOPMENT, PROMOTIONS AND ADVANCED TECHNOLOGIES APPLICATIONS SOCIETY – Member.

SOME OF THE SPECIFIC TRAINING/EDUCATION:

- ✓ PSS/E – 2009, Energy Institut Hrvoje Požar- Zagreb and 2011- Faculty of electrical engineering Tuzla;
- ✓ MAED (Model for Analysis of Energy Demand) - 2009, IAEA (International Atomic Energy Agency) and Energy Institut Hrvoje Požar- Zagreb
- ✓ WASP (Wien Automatic System Planning Package)- 2009, IAEA (International Atomic Energy Agency) and Energy Institut Hrvoje Požar- Zagreb

Also, he is familiar with: NEPLAN, DIGSILENT, PowerCad, Matlab.

SKILLS

- ✓ Power (transmission and distribution) system modelling and analyses (modelling of electric power systems in steady state, during short circuits and during other transients).
- ✓ Power system planning (energy and electricity forecasting, economy analyses of investment in new power generations and components of transmission and distribution grid (NPV, IRR,..), etc.
- ✓ Excellent experience in following software packages – PowerCad (power flow and fault analysis); PSAT (Matlab toolbox)- power flow, stability and security analyses; PSS/E (v33) (power flow,

fault analysis, stability analyses (including all aspects of WPP connection analyses), security analyses (n-1);

- ✓ Experience (periodic applications) in software packages Neplan and Digsilent (power flow, fault analysis and stability analyses);

- ✓ Experience in software package PVGIS (estimations of photovoltaic generation) and practical design of small PVPP.

- ✓ Other software: MS Office, Matlab.

PUBLICATIONS:

PhD thesis – An identification of power system dynamic behaviour using wavelet transform, 2012, University of Tuzla- Faculty of electrical engineering, 2012.

MSc thesis - Voltage stability analysis of the real weak transmission power system, 2006, University of Tuzla- Faculty of electrical engineering

Undergraduate thesis - Methodology of planning power distribution networks- TS 35/10 kV Doboj East case study, 2000, University of Tuzla- Faculty of electrical engineering

Research and development projects

1. Establishing best practice approaches for developing credible electricity demand and energy forecasts for network planning (Paris, 2016.)
Position: member of research team
Funding : CIGRE WG C1.32

Study research:

1. *An impact of reactive power consumption to the losses of energy in power distribution network and the measures to reducing- the Una-Sana Canton case study*, EPC Elektroprivreda B&H, Sarajevo 2003.
   Position: member of research team
   Funding : JP Elektroprivreda BiH

2. *Long-term forecasting of energy, electricity and active power demand – Bosnia and Herzegovina case study'*, EPC Elektroprivreda B&H Sarajevo – Energy Institut Hrvoje Požar- Zagreb, Sarajevo 2011.
   Position: project leader
   Funding : JP Elektroprivreda BiH

3. *Analysis of the current situation and measures to improve the procedures of identification and localization of energy losses in power distribution networks Elektroprivreda BiH dd Sarajevo,* EPC Elektroprivreda B&H, April, 2013.
   Position: project leader
   Funding : JP Elektroprivreda BiH

4. *Perspective of 35 kV voltage level in JP Elektroprivreda B&H, JP Elektroprivreda B&H*, April, 2014.
   Position: project leader

Funding : JP Elektroprivreda BiH

5. *Study on Neutral Point Grounding in Medium-Voltage Distribution Network* (Sarajevo, Februar 2016.)
   Position: project leader
   Funding : JP Elektroprivreda BiH

6. *Energy Efficient Public Lighting—A Case Study (Public Company Roads of Federation Bosnia and Herzegovina)* (Sarajevo, Februar 2016.)
   Position: project leader
   Funding : Public Company Roads of Federation Bosnia and Herzegovina

7. *Application of Capacitors to B&H Distribution Systems* (Sarajevo, Februar 2017.)
   Position: project leader
   Funding : JP Elektroprivreda BiH

OTHER PROJECTS:

1. *Designing of the main project PV 94 kWp Valvet trade Sarajevo, 2016. Sarajevo*
2. *Designing of the main project PV 23 kWp Gnječe - Doboj, 2015. Sarajevo*
3. *Designing of the main project PV 20 kWp Ahimbašići, 2014. Sarajevo*
4. *Calculations of power flow and short circuit into MV grid of WPP Podveležje (45 MW) – Technical report, 2013. Sarajevo*
5. *Connection of small WPP Susa-Visoko into 10 kV power distribution grid- Technical report, 2012. Sarajevo*
6. *Impact of a group small HPP on the local distribution grid in the Vakuf - Technical report, 2011. Sarajevo*
7. *Technical report connection of WPP 2 MW into distribution grid in Podveležje-Mostar, 2010. Sarajevo*
8. *Power flow calculations and losses localisation into all distribution grids in JP Elektroprivreda B&H, 2003-*

Books/Book chapters:

Book:

1. *Electromechanical oscillations in power system – apply techniques for identifications and analyses, University of Sarajevo, 2018. (in Bosnian)*
2. *Advanced Technologies, Systems, and Applications III – Volume 2 –Samir Avdaković, Springer - Verlag 2018 https://www.springer.com/us/book/9783030025762*
3. *Advanced Technologies, Systems, and Applications III – Volume 1 –Samir Avdaković, Springer - Verlag 2018 https://www.springer.com/us/book/9783030025731*
4. *Advanced Technologies, Systems, and Applications II– Mirsad Hadžikadić and Samir Avdaković, Springer - Verlag 2017 https://www.springer.com/gp/book/9783319713205*
5. *Advanced Technologies, Systems, and Applications – Mirsad Hadžikadić and Samir Avdaković, Springer - Verlag 2016 http://www.springer.com/cn/book/9783319472942*

Publications paper over the past five years

Journals:

1. Maja Muftić Dedović, Samir Avdaković, A new approach for df/dt and active power imbalance in power system estimation using Huang's Empirical Mode decomposition, International Journal of Electrical Power & Energy Systems, Vol. 110, pp. 62-71, 2019.

2. N. Čišija Kobilica, Samir Avdaković, Jasna Hivziefendić, Smart transmission system: a new approach for the fault identification, localization and classification in the power system, Journal of Engineering Research (accepted for publications), 2019.

3. Tarik Hubana, Mirza Saric, Samir Avdakovic, New approach for Identification and Classification of High Impedance Faults in MV Distribution Networks, IET Generation, Transmission & Distribution, DOI: 10.1049/iet-gtd.2017.0883 , Online ISSN 1751-8695 Available online: 06 November 2017,

4. Samir Avdaković, Alija Jusić, Dynamic response of a group of synchronous generators following disturbances in distribution grid, Engineering Review, vol. 36, no. 2, 181-186, 2016.

5. Samir Avdaković, Maja Muftić Dedović, Identification of coherent-generator groups using the Huang's empirical mode decompositions and correlations between IMFs, Elektrotehniški Vestnik/Electrotechnical Review, 82(5), 260-264, 2015.

6. Salko Zahirovic, Smail Zubcevic, Samir Avdakovic, Nedis Dautbasic, Maja Muftic Dedovic, Analysis of Electroencephalogram Report Using the Wavelet Transform, Journal of Neurological Surgery Part A: Central European Neurosurgery, vol. 76, S 02, A094, 2015, Thieme

7. S Ibrić, S Avdaković, I Omerhodžić, N Suljanović, A Mujčić, Diagnosis of Epilepsy from EEG signals using Hilbert Huang Transform, Folia Med. Fac. Med. Univ. Saraeviensis, vol. 50 (1), 68-73, 2015.

8. M Veledar, S Avdakovic, Z Bajramovic, M Savic, K Stankovic, A Carsimamovic, Wavelet-based Analysis of Impulse Grounding Resistance–Experimental Study of the "A"-type Grounding System, Electric Power Components and Systems, vol. 43(19), 2189-2195, 2015.

9. S Avdaković, N. Čišija, Wavelets as a tool for power system dynamic events analysis – State-of-the-art and future applications, Journal of Electrical Systems and Information Technology, Volume 2, Issue 1, May 2015, Pages 47–57, http://www.sciencedirect.com/

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13. S Avdakovic, Co-movement of active and reactive power consumption, U.P.B. Sci. Bull., Series C, Vol. 76, Iss. 3, 2014.

14. S Avdakovic, A Bosovic, Continuous Wavelet and Hilbert-Huang Transforms Applied for Analysis of Active and Reactive Power Consumption, Metrology and Measurement Systems 21 (3), 413-422, 2014.

15. Samir Avdakovic, Adnan Bosovic, Impact of charging a large number of electric vehicles on the power system voltage stability, ELEKTROTEHNIŠKI VESTNIK 81(3): 137-142, 2014.

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25. Nejra Čišija-Kobilica, Samir Avdaković (Sarajevo, BiH); Application of Teager Energy Operator for the Power System Fault Identification and Localisation, THE INTERNATIONAL SYMPOSIUM ON ADVANCED ELECTRICAL POWER SYSTEMS (PLANNING, OPERATION AND CONTROL) - (ISAPS), Teslić, BIH, 2017

26. Maja Muftić Dedović, Samir Avdaković, Nedis Dautbašić (Sarajevo, BiH): Application of Hilbert-Huang transform to power system dynamic behavior analyses – a review, THE INTERNATIONAL SYMPOSIUM ON ADVANCED ELECTRICAL POWER SYSTEMS (PLANNING, OPERATION AND CONTROL) - (ISAPS), Teslić, BIH, 2017

27. Maja Muftic Dedovic, Samir Avdakovic, Irfan Turkovic, Nedis Dautbasic, Tatjana Konjic, Forecasting PM10 concentrations using neural networks and system for improving air quality, XI International Symposium on Telecommunications (BIHTEL), 2016, http://ieeexplore.ieee.org/document/7775721/

28. Samir Avdakovic, Maja Muftic Dedovic, Nedis Dautbasic, Jasenka Dizdarevic, The influence of wind speed, humidity, temperature and air pressure on pollutants concentrations of PM10 — Sarajevo case study using wavelet coherence approach, XI International Symposium on Telecommunications (BIHTEL), 2016, http://ieeexplore.ieee.org/document/7775719/

29. M Music, N Hasanspahic, A Bosovic, D Aganovic, S Avdakovic, Upgrading smart meters as key components of Integated Power Quality Monitoring System, 16 IEEE International Conference on Environment and Electrical Engineering, 7-10 June 2016, Florence, Italy

30. Zijad Bajramovic, Irfan Turkovic, Samir Avdakovic, Adnan Mujezinovic, Evaluation of the quality of impulse high voltage measuring system, ICAT 2015, IEEE.

31. Jasmina Čučuković, Emina Hasić, Samir Avdaković, PROCJENA UTJECAJA PUNJENJA ELEKTROMOBILA NA SREDNJENAPONSKU DISTRIBUCIJSKU MREŽU, HRO CIGRE, C6-02, 2015.

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34. S. Avdaković, E. Bećirović, N. Hasanspahić, M. Musić, A. Merzić, A. Tuhčić, J. Karadža, D. Pešut, A. Kinderman Lončarević, "Long-term forecasting of energy, electricity and active power demand – Bosnia and Herzegovina case study", The 4th International Symposium on Sustainable Development (ISSD2013), Sarajevo.

35. E. Bećirović, M. Musić, N. Hasanspahić, S. Avdaković, "Smart grid implementation in electricity distribution of Elektroprivreda B&H – requirements and objectives", The 4th International Symposium on Sustainable Development (ISSD2013), Sarajevo.

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37. M. Music, A. Bosovic, N. Hasanspahic, S. Avdakovic, E. Becirovic, "Integrated power quality monitoring systems in smart distribution grid", Energycon 2012, pp. 557-562, 2012. (ieeexplore.ieee.org)

PhD Mentorships

1. PhD (Doctor of Science) - Nejra Čišija, *Power systems smart fault identification, location and classification based on advanced signal processing and artificial intelligence techniques*, INTERNATIONAL BURCH UNIVERSITY, FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGIES, DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, 2018.

2. PhD (Doctor of Science) - Maja Muftić Dedović, New Approach for Under Frequency Load Shedding, University of Sarajevo, Faculty of electrical engineering, in progress.

BROJ: 02-1-4345/14
DANA, 30.09.2014

Univerzitet u Sarajevu University of Sarajevo

- SENAT –
Broj: 01-38-3301/14
Sarajevo, 24.09.2014. godine

Na osnovu članova 56. tačka j. 155.,157, te članova 162. - 167. Statuta Univerziteta u Sarajevu, odredaba članova 89. i 103. Zakona o visokom obrazovanju prečišćeni tekst ("Službene novine Kantona Sarajevo", broj: 42/13), a u skladu sa prijedlogom Odluke Nastavno – naučnog vijeća Elektrotehničkog fakulteta sa sjednice održane 14.07.2014 godine i pozitivnog mišljenja Grupacije tehničkih nauka održane 16.09.2014 Senat je na 25. sjednici održanoj 24.09.2014. godine, d o n i o

O D L U K U
O IZBORU U ZVANJE
DOCENTA

I

Dr Samir Avdaković bira se u zvanje docenta za oblast: „Elektroenergetika" na Elektrotehničkom fakultetu Univerziteta u Sarajevu.

II

Ova odluka stupa na snagu danom donošenja.

Pouka o pravnom lijeku: Ova odluka je konačna i protiv nje nije dozvoljena žalba ali se može pokrenuti upravni spor pred nadležnim sudom u Sarajevu u roku od 30 dana od dana prijema odluke.

REKTOR

Prof. dr. Muharem Avdispahić

Dostaviti:
-za arhivu,
-fakultetu,
Oimenovanom putem fakulteta
a/a.

Na osnovu člana 88. stav 1) tačka (d) i stav 4) Zakona o visokom obrazovanju („Službene novine Kantona Sarajevo" br. 42/13 - prečišćeni tekst i br. 13/15), člana 112. Zakona o radu („Službene novine FBiH" br. 26/16), člana 26., 28. i 29. stav 1) alineja (2) Pravilnika o radu Elektrotehničkog fakulteta u Sarajevu (br. 04-1-3665/16 od 07.10.2016. godine) i Odluke Senata Univerziteta u Sarajevu (br. 01-38-3301/14 od 24.09.2014. godine), *z a k l j u č u j e se*

UGOVOR O RADU
na određeno vrijeme

između ELEKTROTEHNIČKOG FAKULTETA U SARAJEVU - ID 4200304450006 Univerziteta u Sarajevu, sa sjedištem u Sarajevu u ulici Zmaja od Bosne bb (koga zastupa dekan prof.dr SAMIM /MALIĆ/ KONJICIJA), kao poslodavca i Doc.dr SAMIRA /IBRAHIM/ AVDAKOVIĆ, dipl.ing.el. - JMBG 1211974120024, sa prebivalištem u Sarajevu u ulici Olimpijska br. 37 (u daljem tekstu: Radnik).

Član 1.

Radnik će obavljati poslove radnog mjesta docent na predmetima naučne oblasti "Elektroenergetika" na Odsjeku za elektroenergetiku, u skladu sa Nastavnim ansamblom, pojedinačno za svaku akademsku godinu na Elektrotehničkom fakultetu u Sarajevu.

Poslovi koje će Radnik obavljati su:
- izvođenje predavanja, organizacija i održavanje redovnih, a po potrebi i vanrednih konsultacija, organizacija tutorijala i LV;
- pripremanje pisanih materijala za nastavu sva tri ciklusa studija;
- formiranje, razvoj i izrada programa za opremanje laboratorijskih resursa;
- mentorstva i učešće u komisijama za izradu i odbranu diplomskih, odnosno završnih radova;
- aktivno učešće u radu Vijeća odsjeka, Nastavnonaučnog vijeća i komisija koje formiraju ovi organi Fakulteta;
- učešće o radu organa u koje ga delegira Fakultet;
- produbljivanje znanja iz naučnih i stručnih oblasti u kojima je angažiran na Fakultetu;
- aktivnosti na promociji Fakulteta i područja svoga rada kroz održavanje nastave po pozivu na drugim visokoškolskim ustanovama, nastupe na naučnim i stručnim skupovima, kao i učešće u organizaciji istih;
- aktivnosti u međunarodnoj saradnji, učešće u radu naučnih i stručnih tijela u domaćim i međunarodnim institucijama i organima
- i drugi poslovi u okviru normativnih akata Fakulteta.

Član 2.

Odlukom Senata Univerziteta u Sarajevu (br. 01-38-3301/14 od 24.09.2014. godine), radnik je izabran u naučnonastavno zvanje docent, na period od 5 /pet/ godina, počevši od 24.09.2014. godine.

Ugovor o radu zaključuje se na određeno vrijeme za period od 05.01.2017. do zaključno sa 24.09.2019. godine, tj. do isteka roka izbora u naučnonastavno zvanje - docent, iz stava 1. ovog člana.

Član 3.

Radnik počinje raditi 05.01.2017. godine, u nepunom radnom vremenu od 20% radnog vremena - 8 sati sedmično.

Član 4.

Dužina i raspored radnog vremena, dnevni, sedmični i godišnji odmor i odsustva, regulirani su Pravilnikom o radu Elektrotehničkog fakulteta u Sarajevu br. 04-1-3665/16 od 07.10.2016. godine (u daljem tekstu: Pravilnik o radu).

Član 5.

Za obavljanje poslova iz člana 1. ovog Ugovora, Radniku pripada plaća u skladu sa Pravilnikom o plaćama, dodacima na plaću i naknadama po osnovu rada zaposlenika Elektrotehničkog fakulteta u Sarajevu - prečišćeni tekst br. 01-01-3687/09 od 11.12.2009., br. 01-01-414/10 od 23.02.2010., br. 01-01-4013/10 od 01.12.2010., br. 01-01-1456/11 od 06.04.2011., br. 01-01-2172/12 od 25.06.2012.godine i br. 01-01-3651/13 od 30.09.2013. godine (u daljem tekstu: Pravilnik o plaćama).

Radnik ima pravo na naknade u skladu sa Pravilnikom o radu i Pravilnikom o plaćama.

Član 6.

Ovaj Ugovor o radu prestaje istekom vremena na koji je zaključen, a i iz ostalih razloga propisanih članom 94., 96., 97., 99. i 100. Zakona o radu („Službene novine FBiH" br. 26/16) i članom 75. do 92. Pravilnika o radu.

Član 7.

Radnik, u slučaju otkaza Ugovora o radu bez njegove krivice, ima pravo na otpremninu u skladu sa Pravilnikom o radu.

Član 8.

Na druge uvjete i odnose koji nisu uređenim ovim Ugovorom primjenjivat će se zakon, kolektivni ugovor, Pravilnik o radu i drug opšti akti Fakulteta.

Član 9.

Izmjene i dopune Pravilnika o radu i Pravilnika o plaćama primjenjivat će se od dana njihovog stupanja na snagu i na ovaj Ugovor o radu.

Član 10.

Ovaj Ugovor stupa na snagu sa danom potpisivanja od strane ugovarača. Stupanjem na snagu ovog Ugovora o radu, prestaje da važ Ugovor o radu na određeno vrijeme (br. 06-2-1-4362/14 od 30.09.2014. godine).

Član 11.

Ovaj Ugovor o radu zaključen je u 4 (četiri) istovjetna primjerka od kojih 3 (tri) primjerka pripadaju Fakultetu, a 1 (jedan) Radniku

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