ISSN 1392 – 1215 ELECTRONICS AND ELECTRICAL ENGINEERING 2009. No. 2(90)
ELEKTRONIKA IR ELEKTROTECHNIKA

T190 ELECTRICAL ENGINEERING
ELEKTROS INŽINERIJA

Fuzzy Technique used for Energy Loss Determination in Medium and Low Voltage Networks

E. C. Bobric
Faculty of Electrical Engineering and Computer Science, "Stefan cel Mare" University of Suceava
str.Universitatii nr.13, RO-720229 Suceava, crengutab@eed.usv.ro

G. Cartina, G. Grigoras
Faculty of Electrical Engineering, "Gheorghe Asachi" Technical University of Iaşi
Bd. D. Mangeron nr.51-53, RO-700050 Iaşi, Romania

Introduction

For any territorial energy distribution company, the minimization of the power and energy losses represents a main concern for assuring a healthy administration of the company.

As with any physical process, electric power transmission and distribution requires energy consumption associated with irreversible thermodynamic conversions. This consumption, referred to as “losses in electric networks” is referenced as such in the technical literature and international statistics.

Losses determination for an electric network, based on measurements, represent both technically and economically, a difficult issue. Given the low percentage of the losses in various elements of network and the accuracy of the metering units mounted in installation, the determination, by measuring per element of network losses is obviously not feasible. Therefore, in high and very high voltage networks, the losses determination is achievable by comparing the injected and the withdrawal energy from a contour, since the number of the input-output points is relatively small and a simultaneous reading of the meters is feasible mostly under the actual conditions of the market economy when the transmission network dispose of a metering systems.

In medium and low voltage networks this comparison can only be done in special situations, since in many countries it is not possible an accurate determination of the energy sold for a given period, because, generally, the reading of all the meters takes more than a week. In the medium voltage networks it is possible to perform a post calculation of the technologic losses on those elements whose loading is monitored operatively or even in real time if an appropriate computerized system exists. For the low voltage networks, the post calculation method is not widely used because it is rational only for the study of smaller parts of the network, the manpower and costs involved for metering being less than for the entire low voltage networks analysis. The obtained results can be used as guiding values for the networks with comparable configurations and consumption.

Distributions network are a complex systems, therefore for management and exploitation are necessarily the synthetic information about the event which making in system.

The good precision and large speed of calculus are conditions fairly difficult to simultaneous satisfying, seeing that result precision impose the detailing modeling of process and increase of parameter number consider that input data.

This paper presents an estimation method of load and the methodology for application of this in determination of energy losses, using the fuzzy techniques.

General consideration

Distributions network are interpenetrate per a large surface, characterized by a many elements: feeders, medium voltage distributor, substations, and low voltage distributor and through absence of meters which permitted load monitoring.

The justifications of the power and energy losses determination in distributions network is laborious and as often as not vague if not defer by time variation of load.

In report with classic methods, which use that reference the maximal charge rate of network, this method use the bus load modeling with typical load profile for characteristic days, a dates of length feeders and installed power and loading level of transformer of substations. This method permitted the aborted with increasing accuracy of power and energy losses determinations in distributed network.

Power and energy losses determinations in distributed network are realized through computational of regime, with considerate in network buses load is shaped with typical load profile for characteristic days and with short number by information since network.

The power losses vary with the network configuration. They are associated with the resistive elements of lines and of transformers from substations and can be calculated with relations:

$$\Delta P=\sum_{i=1}^{N_{Tr}}\Delta P_{Tr_i}+\sum_{j=1}^{N_L}\Delta P_{L_j}\ , \qquad (1)$$

$$\Delta Q=\sum_{i=1}^{N_{Tr}}\Delta Q_{Tr_i}+\sum_{j=1}^{N_L}\Delta Q_{L_j}\ , \qquad (2)$$

where ΔP, ΔQ – active and reactive power losses; ΔP_{Tr_i}, ΔQ_{Tr_i} – active and reactive power losses in the transformers i; ΔP_{L_i}, ΔQ_{L_i} – active and reactive power losses on the line i; N_{Tr} – total number of the transformers; N_L – total number of the lines.

Thus, using relations (1) and (2) it can determine the hourly power losses for every level of the load characteristic curves $\Delta P(t)$.

The daily energy loses are determinate with the relation:

$$\Delta W=\sum_{t=1}^{T=24}\Delta P(t)\,. \qquad (3)$$

The electric distribution network have a big number of load's busses even if taken the in consider merely the busses which in place the substation. The consumers connect in the network busses are very numerous, heterogeneous as the absorbed powers, using his technologists the social behaviors, enforcing the particular loops of thing.

Also, in distribution networks there are little information about loading level of transformer of substations. Feeders and loads are not monitoring usually. Therefore, in each moment existing one incertitude degree about buses loads and accordingly and about load level of network, voltage level by buses and power loses.

Uncertainty buses loads are recovering in computational error of permanently regime, which thus affected the trustfulness results.

For resolve this problems is important to fuzzification buses load and loading level of transformer of substations. This paper proposed one method of fuzzification by way that is obtaining good results in distribution network regime analyzing.

Fuzzy techniques

The idea of fuzzy logic was born in 1965. Lofti A. Zadeh published a seminar paper on fuzzy sets, which was the birth of fuzzy logic technology. At the beginning fuzzy logic was strongly resisted, but step by step more studies had been performed. In the decade after Dr. Zadeth's seminal paper many theoretical developments in fuzzy logic took place in the United States, Europe and Japan. These exploited the fact that for example Fuzzy Logic is tolerant of imprecise data, can model nonlinear functions and can be blended with conventional control techniques.

The broad development of mathematical theory especially in areas of Possibility Theory, Fuzzy Control, Neural Networks, and Pattern Recognition provided the basis for different applications. They finally became the driving forces of fuzzy technique that today is reflected in many different software and hardware products.

The basic idea of fuzzy techniques is to model and to be able to calculate with uncertainty. Mathematical models and algorithms in electric power system theory aim to be as close to reality as possible. The required human observations, descriptions, and abstractions during the modeling process are always a source of imprecision.

Uncertainty in fuzzy logic is a measure of nonspecifically that is characterized by possibility distributions. A fuzzy set is set containing elements that have varying degrees of membership in the set. Elements of fuzzy set are mapped to a universe of a membership function. Fuzzy sets and membership functions are often used interchangeably. There are different ways to derive membership functions. Even though the choices of membership function are subjective, there are some rules for membership function selection that can produce good results.

A fuzzy number $\tilde{A}$ can have different forms but, generally, this is represented as triangular or trapezoidal form, usually represented by its breaking points:

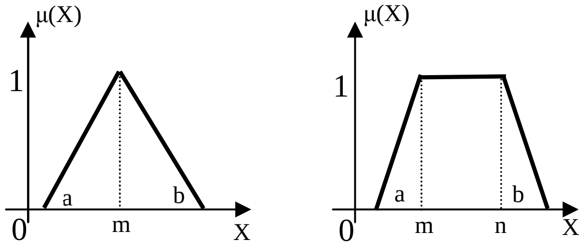

Fig. 1. Triangular and trapezoidal membership function

$$\tilde{A}\Leftrightarrow(x_1,x_2,x_3)=[m,a,b], \qquad (4)$$

$$\tilde{A}\Leftrightarrow(x_1,x_2,x_3,x_4)=[m,n,a,b]. \qquad (5)$$

The proposed linguistic categories for load level of distribution feeders are represented in Fig. 2.

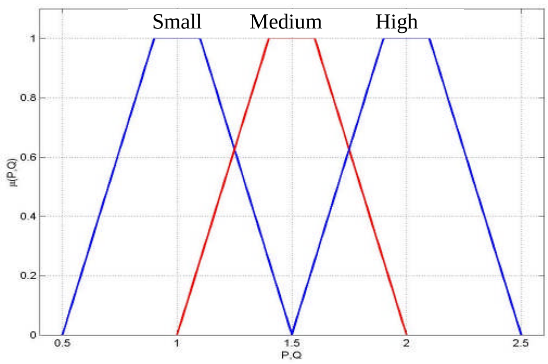

Fig. 2. Membership functions for the loading level of distribution feeders

Determination of hourly active and reactive power losses level, consequential permanently regime calculus of test network distribution, considering the processed linguistic categories, permit the stabling the linguistic category of energy losses.

Case study

The paper presents a model for evaluation the power and energy losses with a good precision, using fuzzy techniques.

The study of operating regimes and determination of voltage, power and energy losses suppose knowledge of repartition of power on each section of network.

Though active and reactive power values circulated on distribution network not is known with accuracy. These are changing in time because of connecting and/or de-connecting from new receivers or because of own consumption characteristics of consumer.

Therefore, for to be effectuated the calculus is used the typical load profiles of the characteristic days (summer and winter period), for each feeder of distribution substation, Fig. 3.

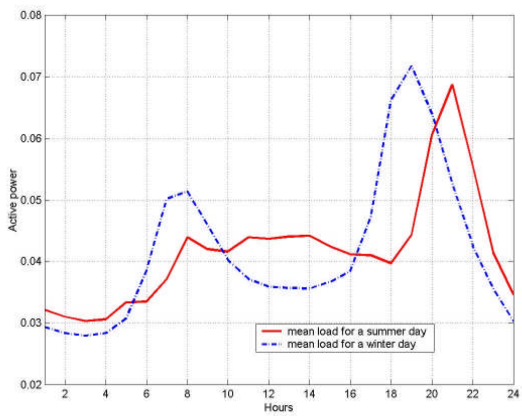

Fig. 3. Typical load profiles for characteristic days

Usually the study period is 24 hours, with measurements at one hour interval. Thus, 24-power flow calculations are needed for an accurate energy losses determination.

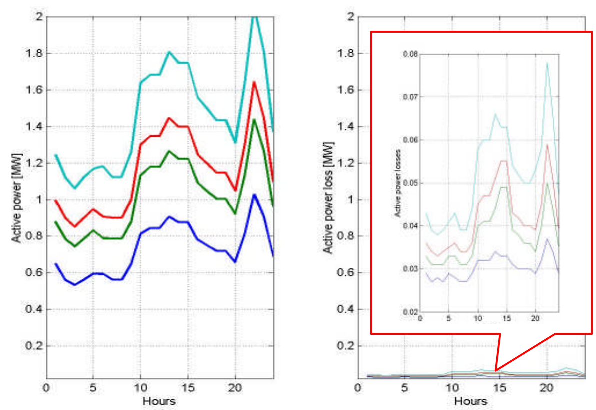

Fig. 4. Typical load profile and power losses profile for summer characteristic day

Fig.4 illustrates the typical load and the power losses profiles, for summer characteristic day corresponding of the fuzzy breaking points of trapezoidal membership function, Table 1.

Table 1. Active power and active power losses for the Medium Level in a characteristic summer day

h	Active power cons. in network [MW]				Active power losses in network [MW]			
	x_1	x_2	x_3	x_4	x_1	x_2	x_3	x_4
1	0.648	0.877	0.996	1.245	0.029	0.033	0.036	0.043
2	0.559	0.784	0.897	1.121	0.027	0.031	0.034	0.039
3	0.529	0.741	0.847	1.059	0.028	0.031	0.033	0.038
4	0.559	0.784	0.897	1.121	0.027	0.031	0.034	0.039
5	0.592	0.828	0.944	1.168	0.029	0.033	0.035	0.041
6	0.590	0.785	0.903	1.181	0.028	0.033	0.036	0.043
7	0.559	0.784	0.897	1.121	0.027	0.031	0.034	0.039
8	0.559	0.784	0.897	1.121	0.027	0.031	0.034	0.039
9	0.648	0.877	0.999	1.261	0.029	0.033	0.036	0.044
10	0.810	1.133	1.299	1.636	0.032	0.040	0.045	0.058
11	0.841	1.177	1.345	1.681	0.032	0.041	0.047	0.060
12	0.841	1.177	1.345	1.681	0.032	0.041	0.047	0.060
13	0.903	1.264	1.445	1.806	0.034	0.044	0.051	0.066
14	0.872	1.221	1.395	1.744	0.033	0.049	0.055	0.063
15	0.872	1.221	1.395	1.744	0.033	0.049	0.055	0.063
16	0.779	1.090	1.246	1.558	0.031	0.039	0.043	0.054
17	0.747	1.046	1.196	1.496	0.030	0.038	0.042	0.052
18	0.716	1.003	1.146	1.432	0.030	0.036	0.040	0.050
19	0.716	1.003	1.146	1.432	0.030	0.036	0.040	0.050
20	0.654	0.916	1.046	1.308	0.029	0.034	0.039	0.053
21	0.810	1.133	1.299	1.636	0.032	0.040	0.045	0.058
22	1.027	1.439	1.644	2.055	0.037	0.050	0.059	0.078
23	0.903	1.264	1.445	1.806	0.034	0.044	0.051	0.066
24	0.685	0.959	1.096	1.370	0.029	0.035	0.039	0.047
Total	17.42	24.29	27.77	34.78	0.73	0.90	1.01	1.24

Table 2. Active power and active power losses for the Medium Level in a characteristic winter day

h	Active power cons. in network [MW]				Active power losses in network [MW]			
	x_1	x_2	x_3	x_4	x_1	x_2	x_3	x_4
1	0.561	0.785	0.897	1.121	0.027	0.031	0.034	0.039
2	0.530	0.741	0.847	1.059	0.027	0.030	0.033	0.038
3	0.499	0.766	0.903	1.181	0.026	0.032	0.036	0.043
4	0.468	0.654	0.748	0.934	0.026	0.029	0.030	0.034
5	0.468	0.654	0.748	0.934	0.026	0.029	0.030	0.034
6	0.499	0.766	0.903	1.181	0.026	0.032	0.036	0.043
7	0.530	0.741	0.847	1.059	0.027	0.030	0.033	0.038
8	0.530	0.741	0.847	1.059	0.027	0.030	0.033	0.038
9	0.623	0.872	0.996	1.245	0.028	0.033	0.036	0.043
10	0.623	0.872	0.996	1.245	0.028	0.033	0.036	0.043
11	0.592	0.828	0.944	1.168	0.028	0.032	0.035	0.041
12	0.530	0.741	0.847	1.059	0.027	0.030	0.033	0.038
13	0.530	0.741	0.847	1.059	0.027	0.030	0.033	0.038
14	0.561	0.785	0.897	1.121	0.027	0.031	0.034	0.039
15	0.904	1.264	1.445	1.806	0.034	0.044	0.051	0.066
16	0.935	1.309	1.458	1.681	0.034	0.046	0.051	0.060
17	1.091	1.527	1.745	2.182	0.038	0.054	0.063	0.085
18	1.181	1.433	1.596	1.995	0.043	0.050	0.057	0.075
19	1.028	1.439	1.644	2.055	0.037	0.050	0.059	0.078
20	0.935	1.309	1.458	1.681	0.034	0.046	0.051	0.060
21	0.873	1.221	1.395	1.744	0.033	0.049	0.055	0.063
22	0.779	1.090	1.246	1.558	0.031	0.039	0.043	0.054
23	0.686	0.959	1.096	1.370	0.029	0.035	0.039	0.047
24	0.686	0.959	1.096	1.370	0.029	0.035	0.039	0.047
Total	16.64	23.20	26.45	32.87	0.72	0.88	0.98	1.18

Proposed method can be compared with other methods for energy loss evaluation, as the method using power losses at the system peak and so on.

To growing the efficiency of the proposed method, the average steady state of the summer (winter) characteristic day can be used. The analysis from the many test networks shows the obtained errors are small.

Using this method, rather precise, robust and simple, it is possible to determinate the energy losses in the in every distribution network.

Conclusions

The paper presents a possible field of application for the fuzzy techniques in the area of distribution network energy losses. In this order loading level of transformer and buses load membership functions are modeled by linguistic variables. This method is addressed to radial distribution network by medium and low voltage where active and reactive power values circulated on distribution network not be known with accuracy, are changing in time.

References

1. **Cârţină Gh., Grigoraş Gh., Bobric E.C.** Clustering techniques in fuzzy modelig. Power szstems applications, published by Cava Venus, Iaşi, 2005.
2. **Eremia M., s.a.** Electic Power Systems, The Publishing House of The Romanian Academy: Bucuresti
3. **Cârţină Gh., Yong-Hua Song, Grigoraş Gh**. Optimal operation and planing of power systems, Casa de Editură Venus, Iaşi 2003
4. **Augugliaro, L. Dusonchet, S. Favuzza, Sanseverino E.R.** Voltage Regulation and Power Losses Minimization in Automated Distribution Networks by an Evolutionary Multiobjective Approach// IEEE Trans. On Power Systems, Vol. 19, No. 3, August 2004, pp. 1516-1527.
5. **Taleski R., Rajicic D.** Energy summation method for energy loss computation in radial distribution network// IEEE Trans. On Power Systems, Vol. 11, No. 2, 1996, pp. 1104-1111.
6. **Cârţină, Gh., Grigoraş, Gh., Bobric E.C.** Power system analysis using Matlab Toolboes, The 6th International Conference on Electromecanical and Power Systems, SIELMEN'07, 2007, Chişinău, Rep. Moldova, Analele Univeritităii din Craiova, Seria Inginerie Electrica, Anul 31, nr. 31, vol II, pp 305-308, 2007, ISSN: 1842-4805.
7. **Albert H, Mihailescu A**, Pierderi de putere şi energie în reţelele electrice, Editura Tehnică, Bucureşti, 1997

Received 2008 12 08

E. C. Bobric, G. Cartina, G. Grigoras. Fuzzy Technique used for Energy Loss Determination in Medium and Low Voltage Networks // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 2(90). – P. 95–98.

Energy losses levels represent an interesting indicator in planning and operation activities of distribution system. This indicator depends by a number of parameters and variables, such as: nominal voltage, transformer capacity, number of substation, electric line parameters, loads level, etc. For energy losses minimization are necessary both development planning, modernization of distribution networks and utilization of management and exploitation techniques, based on intelligent equipment, performance software techniques, which facilitating the realizing of this objective. In this paper is presented the applications of fuzzy techniques for load estimations and determination of energy loss in distribution network. Numerical results make obvious in that presented method is rather precise, robust and simple of applied. Ill. 4, bibl. 7 (in English; summaries in English, Russian and Lithuanian).

Е. Ц. Бобрич, Г. Цартина, Г. Григорас. Нечеткий метод, используемый для определения потерь энергии в сетях среднего и низкого напряжения // Электроника и электротехника. – Каунас: Технология, 2009. – № 2(90). – С. 95–98.

Уровни потери энергии представляют собой интересный показатель в области планирования и эксплуатации систем распределения. Этот показатель зависит от целого ряда параметров и переменных, таких как: номинальное напряжение, мощность трансформаторов, количество подстанций, электрические параметры линии, уровень нагрузки и т. д. Для минимизации потерь энергии необходимы не только планирование развития, но и модернизация сетей распределения, используя технику управления и эксплуатации, основанную на интеллектуальном оборудовании, программах обеспечения эффективности. Предложено использовать нечеткие методы для оценки нагрузки и определения энергетических потерь в сети распределения. Численные результаты очевидно показывают, что метод довольно точный, надежный и простой в применении. Ил. 4, библ. 7 (на английском языке; рефераты на английском, русском и литовском яз.).

E. C. Bobric, G. Cartina, G. Grigoras. Neraiškusis metodas vidutinės ir žemos įtampos tinklų energijos nuostoliams nustatyti // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 2(90). – P. 95–98.

Energijos nuostoliai yra savitas indikatorius, naudojamas planuojant ir vykdant energijos paskirstymo sistemos veiklą. Jis priklauso nuo įvairių parametrų, tokių kaip nominalioji įtampa, transformatoriaus galia, pastočių skaičius, elektros linijos parametrai, apkrovos pobūdis ir t. t. Siekiant minimizuoti energijos nuostolius, būtina tiek tinkamai suprojektuoti paskirstymo tinklus, tiek modernizuoti jų valdymo metodus naudojant intelektualiąją įrangą, efektyvumą didinančias programas. Analizuojamos neraiškiųjų metodų taikymo galimybės paskirstymo tinklų apkrovai ir energijos nuostoliams apskaičiuoti. Skaitmeniniai rezultatai rodo, kad siūlomas metodas yra pakankamai tikslus, patikimas ir paprastai pritaikomas. Il. 4, bibl. 7 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).