Online ISSN 1848-3380, Print ISSN 0005-1144
ATKAFF 57(1), 120–128(2016)

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The application of fuzzy inference systems in overload elimination and correction

DOI 10.7305/automatika.2016.02.1060
UDK 621.311.072.8.051.2.016.35-55; 510.644.4

Original scientific paper

The paper deals with analysis of the safety and stability of a power supply network. In the modern market the need for power system to function near stability margin is increased, and also very close to the permissible limits of thermal limitations of the transmission power system. The known methods for analyses have slow convergence or inadequate accuracy. A fuzzy logic regulator makes the needed adjustments and uses fuzzy inference systems that are based on the settings embedded on knowledge and experience of experts. The basic idea is to develop a fuzzy logic system that will be based on the vulnerability indices of the systems components, and together with the overload factor, represents the input values suitable to control processes. Another goal is the creation of the controller that will allow more efficient way of power system operation by using the safety analysis to eliminate line overloads.

Key words: Fuzzy Inference Systems, Overloads Elimination, Control

Primjena neizrazitih sustava za otklanjanje i korekciju preopterećenja. Rad se bavi analizom sigurnosti i stabilnosti napajanja elektroenergetskih mreža. U modernom tržištu povećana je potreba vođenja elektroenergetskog sustava blizu granica stabilnosti i vrlo blizu dopuštenih termičkih granica elemenata prijenosnog sustava. Poznate metode za analizu sigurnosti se vrlo sporo približavaju rješenju ili imaju nedovoljnu preciznost. Neizraziti sustavi zaključivanja poboljšavaju stare metode otklanjanja preopterećenja elemenata mreže. Neizraziti regulator radi potrebne prilagodbe i koristi neizraziti sustav zaključivanja koji se bazira na postavkama temeljenim na znanju i iskustvu eksperta. Osnovna ideja je razviti neizraziti logički sustav koji će biti temeljen na indeksima osjetljivosti komponenti sustava, koji zajedno s faktorom preopterećenja predstavlja ulaznu veličinu pogodnu za procese regulacije. Drugi cilj je razvijanje regulatora koji bi pridonio puno boljem vođenju elektroenergetskog sustava koristeći analize sigurnosti, kako bi se eliminiralo preopterećenje vodova.

Ključne riječi: neizraziti sustavi zaključivanja, otklanjanje preopterećenje, regulacija

1 INTRODUCTION

In real power system, in order to maintain an acceptable level of security, operators in control centers often have to make quick preventive or emergency corrective measures, especially after the rapid change of load, overload or failure of network elements.

The existing traditional methods for security analysis and eliminating overloads in power system control are using highly complex, highly specific and time consuming mathematical calculations with an extremely complex system [4,5].

Hence there are many uncertainties and ambiguities in the power system the application of standard methods in analysis of power system security has significant deficiencies, either due to the convergence of methods acceptable solution or because of its significant slowness [2].

From the perspective of operators, it is relatively easier to regulate production than eliminating load, and this has motivated a lot of papers on the management of congestion through production redispatching topics [3]. Although sometimes reconfiguration of network is easier than production redispatching, it is a possibility [8].

However, optimization of the system is not major concern when emergencies occur in real time and the dispatcher must regulate production in order to avoid violation of system limitations [7,1].

The application of fuzzy systems in the security analysis, when making decisions to eliminate overloading, in the center of interest the knowledge of an experienced expert is set [11,12]. Settings and regulation in system as decision-making in the power system control is performed by expert system that is based on fuzzy rules.

In power systems implementation and use of fuzzy systems are in the development phase of testing. In this paper an application of fuzzy systems in electric power system control and considerations regarding the application of the same are presented. Base of this research is the proposal of fuzzy system model for removal of overload in the power system network. In doing so, emphasis was placed on the redistribution of power flow and production redispatching in order to prevent overloading of lines.

This paper presents a model and application of a fuzzy logic in power system networks control with the purpose of eliminating overloading of lines and increase in system security. Key measurable properties are the factor of lines overload, Sensitivity Vulnerability Index of Generation Unit - (SVIGS) and General Sensitivity Shift Factor (GSSF).

Key results are shown in a simple example that pointed to the possibility of applying the method based on the reasoning for the elimination of possible overloading of power lines.

This paper is divided into several chapters. Chapter 2 shows the regulation options of the power system and the security analysis problems. Chapter 3 shows the overload elimination method based on fuzzy systems with the definition of input variables of fuzzy systems and the corresponding membership functions. Chapter 4 provides a simple example application to eliminate overloads based on fuzzy reasoning. Finally, section 5 shows the synthesis of a fuzzy model

2 POWER SYSTEM CONTROL

The demands of the market have increased the requirements for the power system control closer to the limits of stability and very close to the permitted thermal limits of the transmission network elements. Specific changes concerning transmission networks have already happened; these networks are often characterized by their frequent congestions and frequent power flow changes for the sake of the rising number of devices used to control the power flow. Furthermore, an increasing number of distributed renewable energy sources is being connected on the transmission and distribution systems making systems even harder to operate because of the limited control options.

The power system has expanded and it is necessary to collect the increasing amount of data that must be processed and forwarded to the appropriate applications within the shortest possible time.

The primary task of system operating is putting the production demands and power expenditure into balance, eliminating the possibility of system failures caused by the system exceeding its safety limits, ensuring the whole system works properly, minimizing production and energy transmission expenditures and ensuring a high level of reliability as well as frequency and voltage control according to applicable regulations.

2.1 Control activities for maintaining security system

The process of operating a system has to be focused on occurrences which significantly lower the system's safety; processes such as cascaded overloads, voltage instability, declines in frequency and the loss of synchronicity between certain areas. The decrease in the system's safety can be a result of loading changes, gear failures or if lightning strikes in the transmission line.

To minimize the impact of the unforeseen events, it is necessary to maintain the system stability while loading and its reliability in order to complete the task and endure the unforeseen state. Figure 1 gives us a schematic look and vision concerning these safety issues, and gives us an insight into the operating processes which use fuzzy logic conclusion as a basis.

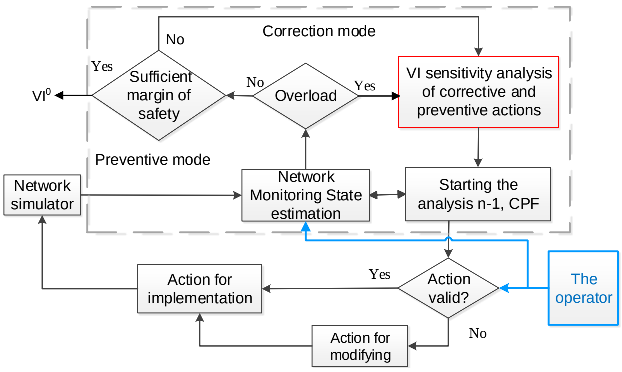

Fig. 1. The possibility of automation application in the power system

In essence, we are talking about a new modified view on Di-Lyacc's [5] vision of helping the operator analyze the system's safety and make decisions in real time. Automatic Operator (AO) gets and updates the information of the network status from the network simulator and performs the estimation of the state. When there is no overload, it is in the preventive mode and it calculates the safety margin of the resulting production and system. If the safety margin is not satisfied, it starts a fuzzy inference system and performs the analysis of vulnerability (VI - Vulnerability Index). If there is overload, the AO is in the corrective mode. This activates the fuzzy inference concluding system and calculates the vulnerability and sensitivity indexes [4]. The final decision in the verification of the estimated state, the system's monitoring and the modification of the suggested action is brought by the operators themselves.

2.2 Security analysis

The exploitation of the power system is almost always planned ahead. This planning process also includes the power distribution and the sustainability of balance between the energy demands and the available production capacities.

The uncertainty of the system can be of great significance and can make the complete safety analysis less reliable. In the operating centers the operator has to constantly control the system and use it economically in such a way in which he ensures its safety [7].

With the available tools, the analysis of the power system can be done in real time, as described in the Fig. 2.

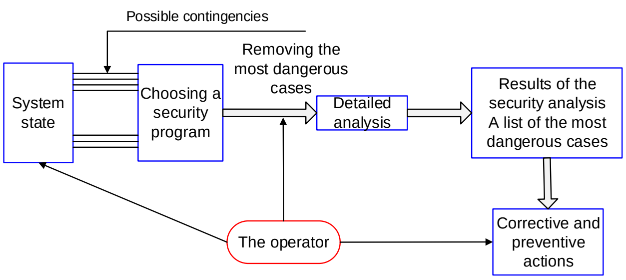

Fig. 2. Procedures of safety analysis

The safety analysis N-1 is an assessment which can be a basis for drawing conclusion on how some specific elements of the network can affect its own safety. It is used to examine the ability of the system to stay stable after some of the elements have malfunctioned. The consequences of particular breakdowns in a system, and which satisfy the safety N-1 criteria, have to have a minimal effect on the work process and the high quality electrical power delivery. When all variables are calculated, they are compared to the values that need to meet the given conditions in order to keep the system safe. If there is a limitation overstep, it is necessary to find a suitable solution for solving those problems.

3 ELIMINATION OF OVERLOAD

While defining the transmission power, towards the N-1 criteria, the system configuration has to ensure that the onetime breakdown of any of the system units does not bring upon a breach in the systems limitations concerning the controlled area and that it doesn't cause a disruption in the power supply.

If the allowed power value in a line crosses the defined and allowed value span in any of the afore-mentioned malfunction cases, the situation preceding the malfunction is considered to be unsafe. The elements of the network which most often endure the breach in transmission power limitations are the transmission lines, and the breaches are almost always caused by the transgression of the allowed power value which is equal to the temperature of the conductor itself.

The highest allowed constant conductor temperatures vary so certain countries asses the highest possible conductor temperature differently as it is shown in Fig. 3.

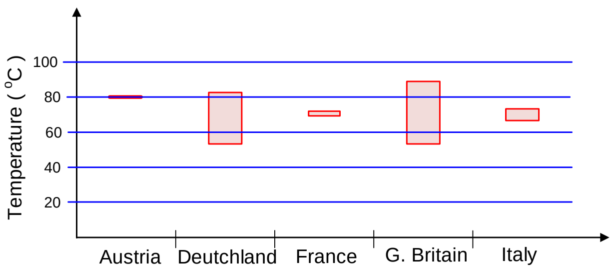

Fig. 3. Limits of maximum temperature guide lines of some countries

In order to avoid the overload of the lines, different expert systems are developed [11]. Therefore operator action is limited to the new distribution of active power.

This chapter describes the different input values used in determining the needed production control, with the goal of removing thermal overloads of endangered lines. The first part will thoroughly describe the sensitivity of change in generator production on the power flows in particular lines.

3.1 The overload factor

For the fuzzy inference system (FIS) the selected input size for the overloaded factor of line *(OF)* is defined by (1):

$$OF_l = \frac{S_{f,l}\,[\text{p.u.}]}{S_{f,l}^{max}\,[\text{p.u.}]}, \quad (1)$$

where the letters represent as follows:
$l = 1, \ldots\ tl$, the number of the lines,
$S_{f,i}$– the power flow through the line l [p.u.], and the,
$S_{f,l}^{max}$ – the thermal overload limit of line l in p.u.

In addition to this, when testing or making adjustments on a fuzzy inference systems because of the overload correction on the lines, and by using the knowledge of experts as a basis for these actions, the only lines chosen and adjusted are those whose OF (overload factors) exceeds the previously defined values.

This value is determined and dependant on the desirable safety margin that is necessary for the needed corrections and to keep the level of data reliability high.

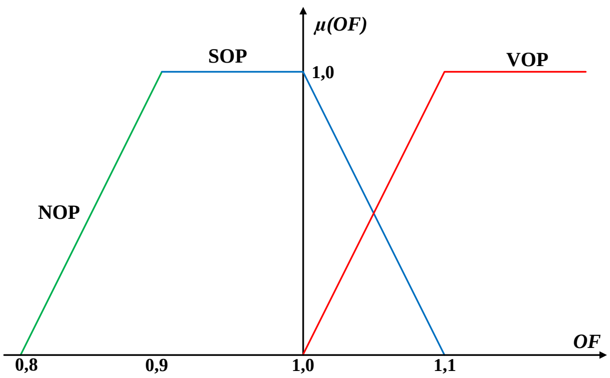

Fig. 4. Membership functions OF

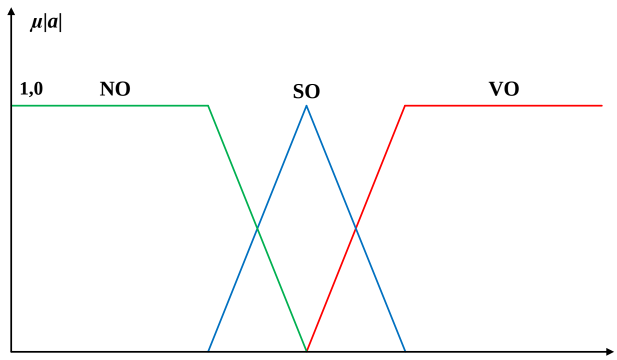

Fig. 5. Membership functions |a|

Membership functions are selected based on expert knowledge of the individual and the time required for the operation in the system, as described in the Fig. 4.

Fuzzy sets are associated to input marked (numbered) sizes are shown in Figure 4, and are designated as: NOP (low loaded), SOP (medium loaded) and VOP (highly loaded).

3.2 The index of production deviation sensitivity

The index of deviation sensitivity or the change of production sensitivity (General Sensitivity Shift Factor – *GSSF*) a_{li} is decribed by the change of the active power in line l and the change of the active power in the generator i:

$$|a_{li}| = \left| \frac{\left(S_{f,l}^{new} - S_{f,l}^{0}\right)}{\Delta P_{g_i}} \right|, \tag{2}$$

where the letters represent as follows:

$l \in \{1, \ldots tl\}$, $i \in \{1, \ldots m\}$;

l – The number of transmission lines in the network

m – The number of generators in the network

$S_{f,l}^{0}$ – The expected base power flow in the line *l*,

$S_{f,l}^{new}$ – The expect power flow after the change ΔP_{gi}

ΔP_{g_i} – The change in the active power of the generator *i*.

The relation between the apparent power value in the line l and change in the efficient power of the generator i gives a new definition of the $GSSF$'s index a_{ii}which is expressed in MVA/MW.

In fuzzy logical system each range of values or absolute sensitivity numerical value is associated with a corresponding membership function that is the input value for the fuzzy decision-making system.

The corresponding membership functions and range of values, as described in Fig. 5.

The corresponding membership functions are labeled so that the NO indicated low sensitivity; with the SO medium sensitivity is marked and VO corresponds to high sensitivity.

3.3 The vulnerability index

The system operators have to know, as precisely and accurately as possible, the condition and status of the system's safety before and during the exploitation of the electric power system. Then they have the possibility, if needed, to take certain control measures. The procedures have to be done when the system's safety is or when it could be compromised. According to Hongbiao, Song, et M. Kezunovic. 2006 [6], the safety of the electric power system depends on the risk level and on its own ability to fight against possible dangers without disrupting the power supply.

The vulnerability can be taken as a measure of attitude towards safety. The system is vulnerable if a power failure can occur in one part of the system, and the element is vulnerable if there is a possibility of breaches of limitation, the appearance of failure or malfunction of the element.

Often used are the static weighting function or indices that may serve well as a basis for increasing the security of the network or the system but their analytical expressions are very complicated and their derivatives are difficult to use in the controlling device based on the sensitivity so vulnerability index (Vulnerability Index - VI) for the determination and allocation of allowable safety factor of individual elements and the entire power system in static conditions is used.

VI expression is based on the so-called performance index (Performance Index - PI) [5], used to select the most critical cases to evaluate the safety of the power system, and in determining the most difficult cases when analyzing the system.

For an *i* measurement of a generator, VI is derived as a half of the square of its real efficient power production and its maximum efficient power output, as is shown in the following:

$$VI_{P_{g,i}} = \frac{1}{2} \cdot \left(\frac{P_{g,i}}{P_{gmax,i}} \right)^2, \quad i = 1, \ldots, m, \tag{3}$$

where, m is number of generators in the network. The higher the value of *VI* is, the more vulnerable the system is.

Similarly, VI j-th line is defined as half the ratio of the square of actual apparent power through the line and maximum apparent power through the line. For the n-th line, the vulnerability index VI is defined as follows:

$$\begin{aligned} VI_{S_{f,i}} &= \frac{1}{2}\cdot\left(\frac{S_{f,i}}{S_{fmax,i}}\right)^2 \text{sa}, \\ S_{f,i}^2 &= P_{f,i}^2 + Q_{f,i}^2 \end{aligned}, \quad (4)$$

where, i = 1,. . . ,tl and tl is number of transmission lines.

Starting from the last equation, it determines the aggregate value in order to determine the index of the vulnerability of the system of generators and transmission lines.

The VI of the whole production system and the system lines is given in the form of:

$$VI_{gen} = \sum_{i=1}^{g} VI_{P_{g,i}} \ , \ \ VI_{line} = \sum_{i=1}^{tl} VI_{S_{f,i}} \quad (5)$$

The greater the value of the vulnerability index, the more vulnerable the system is. The main task is to calculate VI in conditions of variable part of production of generator and determine the impact of the vulnerability index as on the level of elements, so and on the level of the entire system.

3.3.1 The sensitivity of the vulnerability index in generator system and derivation of the vulnerability index

In the previous chapter, we determined the VI of a generator system using (5). Equation (6) defines and determines the sensitivity of the VI of a generator system $SVIGS$ in the following way:

$$\begin{aligned} SVIGS_i = \frac{\partial VI_{gen}}{\partial P_{g_i}} &= \frac{1}{2}\left(\frac{\partial}{\partial P_{g_i}}\right)\left[\left(\frac{P_{g_i}}{P_{gmax_i}}\right)^2\right] \\ &= \frac{P_{g_i}}{P_{g_{i,max}}^2}. \end{aligned} \quad (6)$$

$SVIGS$ index is defined by the relation between the derivative VI vulnerability index of generator system and the derivation of the active power of each production unit. It can also be shown as the relationship between the current active power of each generator and the square of its maximum active power.

The generator with the maximum sensitivity is the one with the highest maximum power output.

For practical reasons, the resulting factor $SVIGS$ must be determined by the power of generator with the largest maximum/minimum power output, precisely with $min\left(P_{gmax,1},\ P_{gmax,2},\ldots,P_{gmax,n}\right)$ as follows:

$$\begin{aligned} &SVIGS_{norm,i} = \frac{P_{g_i}}{P_{g_{i,max}}^2 \cdot SVIGS_{max}} \\ &sa\ \ SVIGS_{max} \\ &= \frac{1}{\min(P_{gmax,1}, P_{gmax,2}, \ldots, P_{gmax,g})} \end{aligned} \quad (7)$$

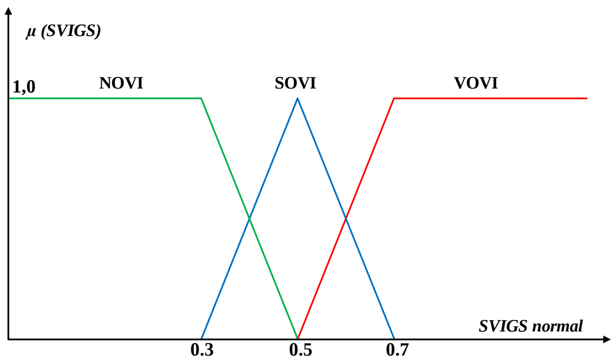

Fig. 6. SVIGS membership functions

The normalized values of $SVIGS$ have the value between 0 and 1. Heuristics behind this choice of value span is to simplify as much as possible the process by which we get 3 balanced categories, the simpler choice of choosing the appropriate membership function which may be used as input values in an fuzzy controller, as described in the Fig. 6.

The corresponding membership functions are labeled so that the NOVI marked low sensitivity, SOVA stands for medium sensitivity and high sensitivity is marked with with VOVI. Those values are the input variables for fuzzy decision-making system.

4 APPLICATION - A SIMPLE EXAMPLE

To compare the different methods of overload elimination it is necessary to observe them on a simple example of a network. Let's observe the following system from Fig. 7. where we can see 2 generators marked $G_1$and $G_{2,}$2 transmission lines L_1 and L_2, and one overload. The given system has no losses concerning the lines. Let's observe the following two cases:

- in the first case marked a), both lines, with defined thermal limits, are available and in function; and
- in the second case marked b), the assumption is that one line L_2 is not available for performing the given function, while the line L_1 is in function.

The data on the power of the generator and initial flow power of the system before the overload occurred are shown in p.u measurement (1 p.u=10 MW) in the Table 1.

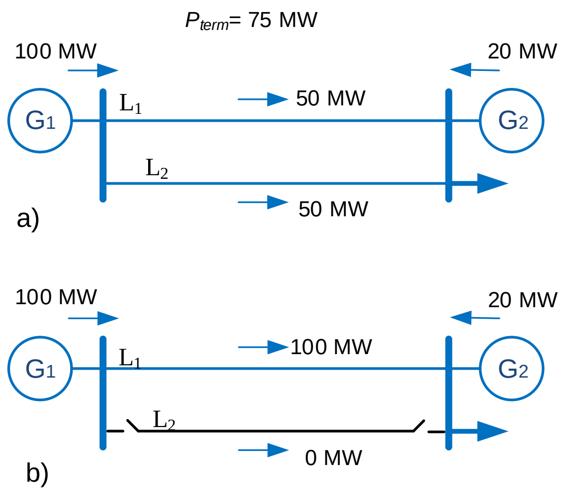

Fig. 7. Illustration of malfunction elimination

Table 1. The power flows in the network's branches before a possible malfunction

	G_1	G_2	L_1	L_2	***Overload***
P_n	10	2	5	5	12
P_{max}	10	7	7,5	7,5	
VI	0,5	0,041	0,222	0,222	

With the previously defined different expressions, the indexes VI hold the following values:
$VI_{gen} = 0,541 \wedge VI_{line} = 0,444$,
$V_{line} = 0,884$ => $VI_{eli} = 0,933$.
The sensitivity matrix $GSSF$ is:

$$\begin{bmatrix} a_1 & a_2 \\ a_3 & a_4 \end{bmatrix} = \begin{bmatrix} 0,5 & -0,5 \\ 0,5 & -0,5 \end{bmatrix}.$$

The sensitivity vector $SVIGS$ is:

$$\begin{bmatrix} 0,1 \\ 0,041 \end{bmatrix}.$$

The system data in the case where one line is unavailable depicted in the Fig. 4. b), is shown in the p.u. in the following Table 2:

Using the different expressions we derive the VI index:
$VI_{gen} = 0,541 \wedge VI_{line} = 0,889$,
$VI_{line} = 0,441$ => $VI_{eli} = 0,933$.

Table 2. The power flows in the network's branches after a possible malfunction

	G_1	G_2	L_1	L_2	***Overload***
P_n	10	2	10	0	12
P_{max}	10	7	7,5	7,5	
VI	0,5	0,041	0,889	0	

The sensitivity matrix $GSSF$ then is:

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 0 & 0 \end{bmatrix}$$

The sensitivity vector $SVIGS$ then is:

$$\begin{bmatrix} 0,1 \\ 0,041 \end{bmatrix}$$

The overload factor of the line:

$$OF_1 = 1,333$$

On the GI list the coefficient with the negative algebraic sign is a_{12}, while on the GD list it is a_{11}. The overload factor OF_1 is used as an input value in the conclusion system: $OF_1 = 1,333$=> OF_1 is VOP.

By applying the algorithm on the generator i=2, an input variable $GSSF$ is acquired:
$|a_{12}| = 1 \rightarrow |a_{12}|$ is VO.

For the before mentioned value $SVIGS$, the membership functions gives out 2 results:
SVIGS$_2$= 0,041 =>*SVIGS*$_2$ is NOVI and *SVIGS*$_2$is SOVI.

Following the base rules of the fuzzy inference system the following results are derived and shown:

1. OF_1 is VOP;
2. $|a_{12}|$ is VO
3. *SVIGS*$_2$ is NOVI *SVIGS*$_2$ is SOVI

Using theses 3 input values, rules 25 and 25, and the output values for the correction of the generator's power we can conclude that $X_1^{25} = V$ and $X_1^{26} = S$ (high and middle). Using the expression depicted by (4.1) as a base:

$$X_i^{out} = \max\left(\begin{bmatrix} X_{li}^1 \\ \vdots \\ X_{li}^{27} \end{bmatrix}\right) \in [0,\ 0.5,\ 1,\ 1.5\,], \quad (8)$$

the following values are derived $X_{12}^{25} = 1.5$ i $X_{12}^{26} = 1.0$

Because the final output value X_2^{out} is also the maximum value, we conclude the following:

$$X_2^{out} = X_{12}^{25} = 1.5.$$

The power flows after the possible malfunction and the power flows after the correction, measured in p.u. (1 p.u.= 10 MW) are shown in the Table 3.

By using Table 3 as a starting point, we can see that the correction of the overloaded lines accomplished by the

Table 3. Power flows after possible malfunction and after correction

	P_{G1}	P_{G2}	P_{L1}
After the malfunction	10	2	10
OA	6.1	5.9	6.1
Method GSSF	5.45	6.55	5.45
Max flow	10	7	7.5

Table 4. VI indexes after a possible malfunction and correction

	VI_{G1}	VI_{G2}	VI_{line}	VI_{gen}	VI_{eli}
After the malfunction	0.50	0.04	0.89	0.54	0.93
OA method	0.19	0.36	0.33	0.54	0.68
GSSF method	0.15	0.44	0.26	0.59	0.70

$GSSF$ method is cheaper and more efficient than the OA method.

Despite this advantage, Table 4 shows that the vulnerability index VI_{eli} of the OA method is lower than the one of the $GSSF$ method, which results from the superior production control process seen in the OA method.

Figure 8 sums up and compares the power flows after the correction of the generator's power production. One can notice that the 2 methods are analyzed, both of them concerning overload removal, $GSSF + SVIGS$ and the $GSSF$ method.

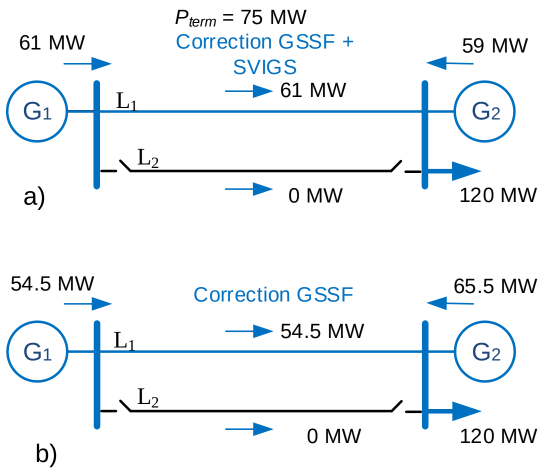

Fig. 8. The state after the possible malfunction and correction

This simple example gives us the possibility to undoubtedly conclude that the $GSSF+SVIGS$ method will be more efficient when it comes to controlling the production of effective power close to the nominal power of the generator, because it avoids unnecessary overloads of the generator when attempting to remove the line overload.

5 THE SYNTHESIS OF THE FUZZY INFERENCE SYSTEMS AND THE ELIMINATION OF FUZZY LOGIC OVERLOAD

In the synthesis of the fuzzy inference systems the designer describes the linguistic rules to change the output size in relation to the input. Fuzzy rules are conditioning declarations in which the causal part represents a condition in the domain of its own use, and the consequential part represents the handling effect on the system that is being controlled. These rules can be derived from man's own experience; by observing the work of an experienced operator while he is controlling a sophisticated dynamic process as it is shown in Fig. 9.

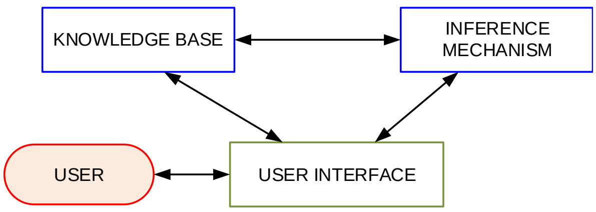

Fig. 9. Block diagram of an expert system

Figure 10 represents a schematic depiction of a complete fuzzy controller with marked input values and indexes (OF, $SVIGS$, $GSSF$). These 3 values are divided into 3 categories, that is, 3 spans of values. Sizes $SVIGS$ and $GSSF$ can have values between 0 and 1, and the size of the OF can have values between 0 and 1.2 as much as in a shorter period of time a power line can be overloaded.

These sizes are input parameters in the (FIS). Each range of values of individual normalized input parameters OF, $SVIGS$and $GSSF$ defines the specific value of affiliation functions (μ).

The number of rules depends on the number of inputs and input states, as seen in Table 5:

Each fuzzy value of affiliation function (μ) for one value of the size OF, $SVIGS$ and $GSSF$ gives one output fuzzy value described by N, M, S, V (zero, small, medium and large). These same values are defined by a set of base rules, or in this case 27 rules of concluding. Table 5 presents the results defuzzification.

The scheme is appropriate for the correction of the generator's output power with the goal being the elimination of one overloaded line. The definitions of specific designations apply with the assumption that "i" is the generator

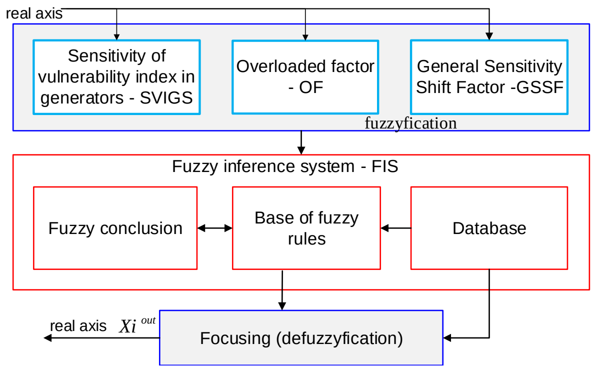

Fig. 10. Block diagram of fuzzy regulator with fuzzy inference

Table 5. Table 5. Fuzzy inference system rules

	OF	$\|a_{li}\|$	**SVIGS**	X^r_{li}
1	NOP	NO	NOVI	M
2	NOP	NO	SOVI	M
3	NOP	NO	VOVI	N
4	NOP	SO	NOVI	M
5	NOP	SO	SOVI	M
6	NOP	SO	VOVI	N
7	NOP	VO	NOVI	M
8	NOP	VO	SOVI	M
9	NOP	VO	VOVI	N
10	SOP	NO	NOVI	M
11	SOP	NO	SOVI	M
12	SOP	NO	VOVI	N
13	SOP	SO	NOVI	S
14	SOP	SO	SOVI	M
15	SOP	SO	VOVI	N
16	SOP	VO	NOVI	S
17	SOP	VO	SOVI	S
18	SOP	VO	VOVI	M
19	VOP	NO	NOVI	S
20	VOP	NO	SOVI	M
21	VOP	NO	VOVI	N
22	VOP	SO	NOVI	V
23	VOP	SO	SOVI	S
24	VOP	SO	VOVI	M
25	VOP	VO	NOVI	V
26	VOP	VO	SOVI	S
27	VOP	VO	VOVI	M

index, "i" / the index of the overloaded line, and X the value derived from the rules of fuzzy logic concluding. All membership functions are linear because that way the results are easier to examine, especially during unfuzzying.

Table 6. Defuzzification

Fuzzy X_i	**N**	**M**	**S**	**V**
Defuzzification X_{ri}	0	0,5	1	1,5

6 CONCLUSION

The tools for network control have started to improve because of implantation of renewable energy sources, particularly the wind power, and with more frequent changes of production in photovoltaic and wind power as well as the strong growth of hourly transactions between interconnection networks. All this contributes to the increase in the required activities within the hourly transactions during system control. There is a whole variety of tools which can be used to analyze the safety and stability of a network, but still, their application is limited, their speed is either not fast enough or is just unacceptable because of the limits of the analysis itself due to the slow speed of the convergence method or inadequate accuracy.

For the system control there are a lot of tools for the analysis of security and stability whose application is limited, not fast enough or unacceptable because of the limitations of the method of analysis, slow method of convergence or insufficient accuracy. The possibilities of applying automation to assist the operator in maintaining power system in order to eliminate overloading of transmission lines and increase the security of the system are explored. A simple example of the application clearly explains all of this.

An example which shows the development of this type of a system model is given depicting the aim of substituting a trained control and guidance operator thus making the whole system more reliable and secured. In connection to the development of this type of a system model, a regulator model has been constructed; its application is based on fuzzy logic conclusion, which itself is based on stored information of the fuzzy inference system, and which has the purpose of recognizing and eliminating line overloads on transmission power lines.

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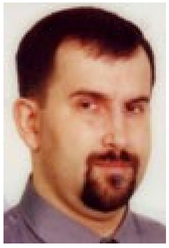

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Received: 2014-10-16
Accepted: 2016-01-18