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MANAGING SHUNT REACTORS IN ACCORDANCE TO FUZZY CONTROLLERS FOR STABILIZATION OF VOLTAGE IN HIGH TENSION TIRE-COVER

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Abstract- Synthesis of controllers forming of managing influences in accordance to fuzzy logic for carrying out of effective management of shunt reactors' power have been implemented in order to compensation of load capacity to extreme high voltage transmission lines. It was also noted that, changes in uncertainity depending of different factors of electric network parameters, writing with non-linear equations of managing object is establishing big difficulties in applying of traditional mathematical techniques. Depending on price of line load reactance, pattern management distortions getting from computer realization of fuzzy control algorithm taking into accordance of reactor power and inductive resistance is affirming of efficiency of this method.

Keywords: High Voltage Power Transmission Line, Shunt Reactors, Natural Power, Fuzzy Controller, Fuzzy Cluster, Membership Function, Management.

I. INTRODUCTION

Technical and economical requests on electric power transmission lines from big power plants and connection with energy system are much more increased in modern period. First of all, decreasing of special capital statement on new constructed and improved available lines is in the center of the attention. Solution of this statement depends on increasing of turn on ability of transmission lines and controlling of transmission power (especially on accident and after accident regimes).

Investigations shows that, total compensation of loading power generating taken into consideration with C_W capacity and it happens with crossing natural power ($P/P_{nat}=1$), demanding L_W inductance and these process happen in equality of electric and magnet areas: $C_W U^2/2 = L_W I^2/2$. In this case, the length of the line will be nominal according to the tension. The tension is changing during changing processes of transmission power. In special situation, during very few loadings of the line ($P/P_{nat}<1$) compensation of its loading power has been causing to its loading power generation ($Q/P_{nat}<0$) and it makes opportunity tension loading on tire-covers of the lines and s/s.

Traditional method of approaching to incomplete indemnification transmission lines, can be the course to sufficiently loading. For this purpose, decreasing of electric energy necessity and transmission power from transmission lines demands increasing compensation degree from 40-50 to 80-120 % at electric networks by 330 kV [2].

Using of shunt reactors (SR-LR1, LR2) for compensation of loading power of TL by 330 kV is one of the most efficient methods (Figure 1). Shunt reactors by 110-1150 kV is widely used as new constructed, reconstructed and commissioned electric networks. Reactors can be constructed not only on tire-covers of TL but also on s/s point of view of line loading power compensation. Construction of SR on the lines especially in long networks is much more expedient action and after eliminating of single-phase short circuit on the line, put out of electric arc process on single-phase automatic connection has been solving.

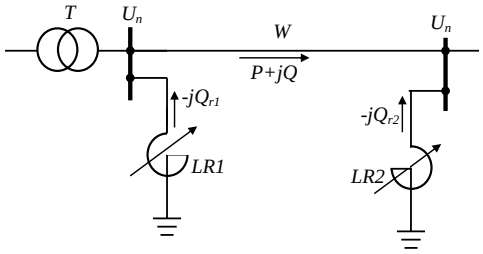


Figure 1. Scheme of connection of shunt reactor to the line

Analysis of characteristics of TL shows that, applying of managing shunt reactors or substituting of available not managing SR is increasing used efficiently of TL in transmission power range. The fact is that if there is a constant tension in connected erased allowed only to the extent of 40-50% due to the decrease in the transmission line for the transmission of natural power. In other hand, the transmitted power is often daily changes in SR problems arise due to the limited resources of the switching high voltage equipment. Thus, the introduction of high-voltage electric networks SR-managed more reasonable and appropriate. There are many control methods traditionally erased [3]:

Reactor Thruster Group based administration; longitudinal, transverse and circumferential algorithm constant current control; transformer reactors management; Management based on the vacuum reactor groups. SR-in precise mathematical models based on traditional management practices for the implementation of the control law, the line parameters, the parameters that characterize the regime cannot fully take into account the likely non-specific changes. So, depending on climatic conditions and changes in the power system parameters, single-ended mode non-sinusoidal load modes change indefinitely, but also to the very high cost of traditional applied to the automatic control means, the complexity of the work and so on.

Taking into account such factors as the general law of traditional mathematical formulation technology creates great difficulties and in some cases virtually impossible [4-8]. In such circumstances, the real-time management of SR efficiently automatically turns down the traditional methods, a sudden sharp change in mode occurs during commutation. Let's note that, in terms of performance requirements, which take into account the impact of these factors, as well as modern SR network intelligence power to adopt the strategy in the field of synthesis and application of modern unconventional management technology is offered as a matter of urgency.

The purpose of reactive power compensation in high-voltage electrical networks shunt reactors used in the control system based on the theory of fuzzy logic method for the synthesis and development of appropriate algorithms.

II. BASES OF APPLYING OF SHUNT REACTORS MANAGEMENT OF FUZZY LOGIC THEORY

Modern computer technology and new programming technology is quite complex and at the same time enables powerful algorithms. The emergence of new methods in connection with the fact that traditional methods of solving problems arising from the need to face a lot of problems. Thus, conventional methods and input parameters to take into account the accuracy of the vector does not contain ambiguity. They have the ability to adapt to changes in the state of the object, leading to the creation of artificial intelligence based on adaptive intelligent systems.

In this respect, as in other areas, recently proposed due to intelligent systems with the use of computer technology issues Soft base realize and technical management preferred by L.A. Zade is superlative [9-11]. One of these methods "fuzzy logic", which is known as the fuzzy set theory has been applied in a wide range of mathematics. The device, created with the use of fuzzy controller devices have certain advantages compared with the traditional algorithm of managed devices.

Fuzzy approach is associated with several advantages: the ability to work with non-numerical data; realizing simplicity and ease of implementation and so on. Management of non-linear differential equations written fuzzy control object efficiency is much more notice. Above cases, there is need to solve the equations.

The government decision to limit errors in permitted. At the same time it should be noted that traditional methods of data entry while searching for a solution of the current uncertainty in terms of the level of misconduct justified. Control systems based on the theory of fuzzy logic rules such shortcomings, it is easier and cheaper [12, 13]. Thus, the high voltage power lines to compensate for reactive power load mode depending on shunt reactor control devices to implement the use of fuzzy logic has been set.

It is known that the high-voltage line C_W, the wave resistance $Z_d = \sqrt{X/B}$, loading power $Q_d = U_{nom}^2 \cdot B$, strength and natural power $P_{nat} = U_{nom}^2 / Z_d$ of water caused by the power lines [1-3]. At the same time the burden of reactor power (or Z load resistance) dependence is expressed as follows [14]:

$$Q_r = P_{nat} \cdot \lambda \cdot \left[1 - \left(\frac{P}{P_{nat}} \right)^2 \right] \cdot l \quad (1)$$

The above-mentioned reasons, it is written into the reactor shunt addictions $\tilde{Q}_r = f(\tilde{P})$ or $\tilde{Q}_r = f(\tilde{Z})$ dependence on government creates crime, based on the theory of fuzzy logic can be implemented. Thus, the burden or load resistance line, depending on the price of the energy reactor power Q_r or inductive reactance Q_r depending on the parameters of fuzzy linguistic model has been developed, however, it can be controlled by the algorithm. $\tilde{Q}_r = f(\tilde{Z})$ recognizing dependence of fuzzy control algorithm developed.

Obviously, $Z = \infty$ the operation load line $(P/P_{nat} = 0)$ and the reactor should be mode maximum reactive power consumption ($Q_r \Rightarrow \max$), the power line working natural regime $Z = Z_d$ and ($P/P_{nat} = 1$) and consumption of reactive power of the reactor must be $Q_r = 0$. Thus, in accordance with changes in a range from TL load resistance, $Z = Z_d \div \infty$ inductivity reactor to be started. For this purpose, the following is considered a fuzzy controller synthesis. It is known that any fuzzy controller (FC), fuzzy and mechanism to extract (Figure 2) [4-13].

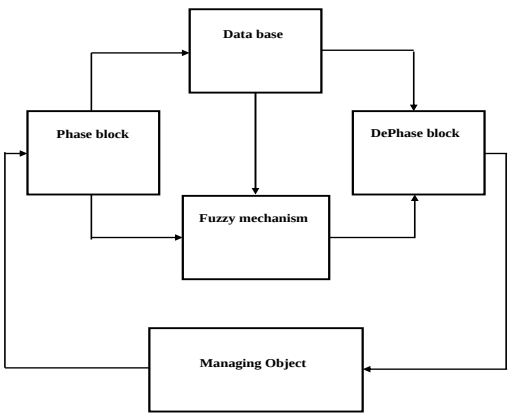


Figure 2. Structural scheme of fuzzy controller

if $X \quad A_i -$ in this way $Y \quad B_i -$, $i = \overline{1, n}$ (2)

One input and one output are for X position management. In this way, linguistic variables and variables, including the management; A and B are generic and sets variables X and Y terms linguistic rates, in other words, and so on $\forall x \ \ A \in E_1$.

Function accessories X linguistic Gauss type for changing the vector has been adopted: $\mu(x) = \text{gaussmf}(x, P)$ [8-12]: FC synthesis reactor using the following simple linguistic fuzzy model can be performed:

$$\mu(x) = \exp\left(\frac{-(x-c)}{2\sigma^2}\right) \quad (3)$$

where, P = [c, *spruce*] setting function; c is the maximum position; and ratio of concentrations $\mu_A(x): X \to [0,1]$.

The form and function of consequences type of the fuzzy affiliation scope have been appointed by the parameters which affecting on the fuzzy output signal.

III. FUZZY MANAGING ALGORITHM OF REACTOR

The control algorithm used in the preparation of the Mamdani algorithm. Programming algorithm (reactive power reactor demand load line approach) input (load resistance) and output units (reactors, reactive power), following a fuzzy term, partitions, FC introduction of "Cargo resistance" were adopted linguistic variables, where, $T_i(Z)$, $Z_i \in E_{1i}$ with $i = \overline{1,5}$:

$$\begin{aligned}
&E_{11} = SB \quad (\text{Very Big}) \ \underline{\underline{\Delta}}\left(Z, \mu_{11}(Z)\right) \\
&E_{12} = B \ (\text{Big}) \ \underline{\underline{\Delta}}\left(Z, \mu_{12}(Z)\right) \\
&E_{13} = M \ \ (\text{Middle}) \ \underline{\underline{\Delta}}\left(Z, \mu_{13}(Z)\right) \\
&E_{14} = S \ \ (\text{Small}) \ \underline{\underline{\Delta}}\left(Z, \mu_{14}(Z)\right) \\
&E_{15} = N \ \ (\text{Natural}) \ \underline{\underline{\Delta}}\left(Z, \mu_{15}(Z)\right)
\end{aligned} \quad (4)$$

In the 500 kV, 287 natural resistance to the wave of acceptance for the Mo ($P_{nat} = 870$ MW) [3], Z "load resistance" is from a linguistic $Z = (287 \div \infty)$ Ohm variable price range (Figure 3(a)).

These prices correspond $P = (870 \div 0)$ MW to the price of the power is transferred to the variable Z line and are generated randomly.

$$\begin{aligned}
&E_{21} = \max \quad (\text{Maximum}) \ \underline{\underline{\Delta}}\left(L, \mu_{21}(L)\right) \\
&E_{22} = B \ (\text{Big}) \ \underline{\underline{\Delta}}\left(L, \mu_{22}(L)\right) \\
&E_{23} = M \ \ (\text{Middle}) \ \underline{\underline{\Delta}}\left(L, \mu_{23}(L)\right) \\
&E_{24} = S \ \ (\text{Small}) \ \underline{\underline{\Delta}}\left(L, \mu_{24}(L)\right) \\
&W_{25} = Z \ (\text{Zero}) \ \underline{\underline{\Delta}}\left(L, \mu_{25}(L)\right)
\end{aligned} \quad (5)$$

Appointed in accordance $\mu_{1i}(Z)$, $\mu_{2j}(Q_r)$ are with the universal set of linguistic identification functions term variables Z and Q. "Reactive Power" is set in the range $P = (870 \div 0)$ MW of linguistic variables prices (Figure 3(b)).

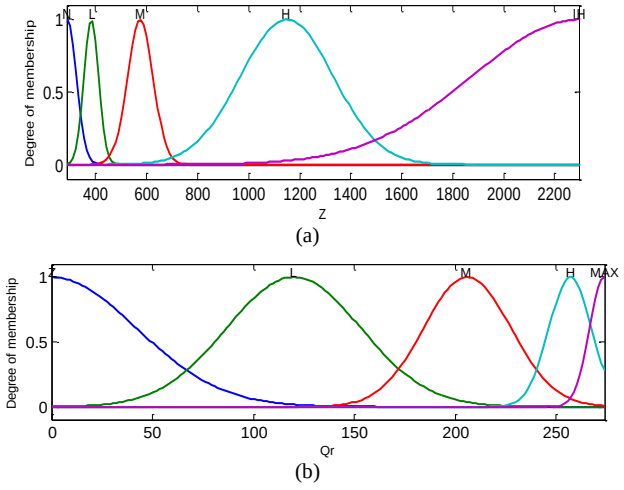


Figure 3. Linguistic input and output variables Z and Q_r terms (a) Z as variable; (b) Q_r as variable

Gauss type of parameters that characterize the functions belonging to linguistic variables terms prices are shown in Table 1.

Table 1. Terms of linguistic input and output variables, functions and parameters of identity

Term-Majority	Functions of Identity	Parameters
Load Resistance		
Very Big	Gauss type	[425,86 2300]
Big		[182,75 1150]
Middle		[50,22 575]
Small		[29,38 383]
Natural		[29,38 383]
Reactive Power		
Maximum	Gauss type	[7,33 274]
Big		[10,54 257]
Middle		[21,66 206]
Small		[33,27 120]
Zero		[42,03 0]

The Equations (4) and (5) of the reactor on the basis of linguistic models inductivity "if - else" format of fuzzy algorithm are formulated in the following way:

$$\begin{aligned}
&\text{if} \quad Z = SB \quad \text{then} \quad Q_r = \max \quad \text{else} \\
&\text{if} \quad Z = B \quad \text{then} \quad Q_r = B \quad \text{else} \\
&\text{if} \quad Z = M \quad \text{then} \quad Q_r = M \quad \text{else} \\
&\text{if} \quad Z = S \quad \text{then} \quad Q_r = S \quad \text{else} \\
&\text{if} \quad Z = NT \quad \text{then} \quad Q_r = ZR
\end{aligned} \quad (6)$$

Apparently, five simple implication consequences of the scope of the vague and fuzzy relationship were organized between the parameters R, R_i (= 1, 2, ..., 5) and can be installed as a set of fuzzy relations:

$$R = \bigcup_{i=1,5} R_i = \bigcup_{i=1,5} E_{1i} \times E_{2i} \quad (7)$$

$$\mu_R(Z, L) = \max \begin{Bmatrix} \min\left[\mu_{E_{11}}(Z), \mu_{E_{21}}(Q_r)\right], \\ \min\left[\mu_{E_{12}}(Z), \mu_{E_{22}}(Q_r)\right], \\ ,..., \min\left[\mu_{E_{15}}(Z), \mu_{E_{25}}(Q_r)\right] \end{Bmatrix} \quad (8)$$

The max-min composition was used in the work.

For other words, managing the impacts of fuzzy space smooth transition space for managing impacts static

better strategy to use precision in the center of gravity is [13-16]:

$$z_0 = \int_{\Omega} z\mu_{\Sigma}(z)dz \Big/ \int_{\Omega} \mu_{\Sigma}(z)dz \quad (9)$$

where, n is the number exit quantum levels.

IV. COMPUTER MODELING RESULTS

The Equations (6)-(8) based on linguistic patterns in Figure 4, the reactor load shunt random fluctuations of uncertainty depend on the implementation of the proposed algorithm computer comprises fuzzy control results. 100 MVA Modeling RODC-100 / 500U1 type 500 kV, depending on the work load reactor shunt arithmetic long line methods were linked. Simulation Z random variation curve shown in Figure 4.

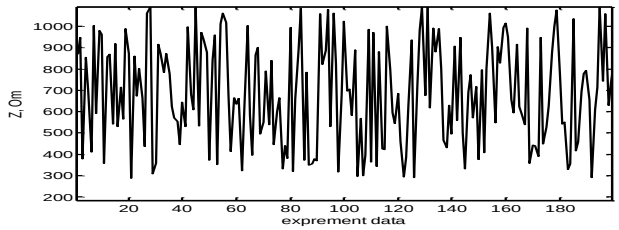
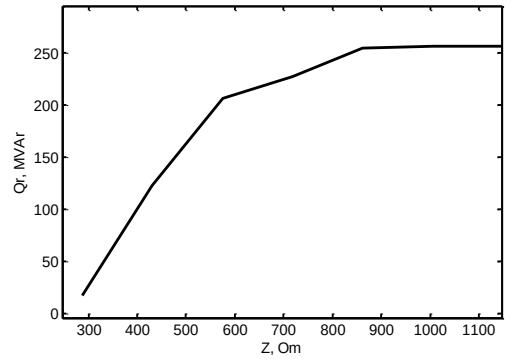
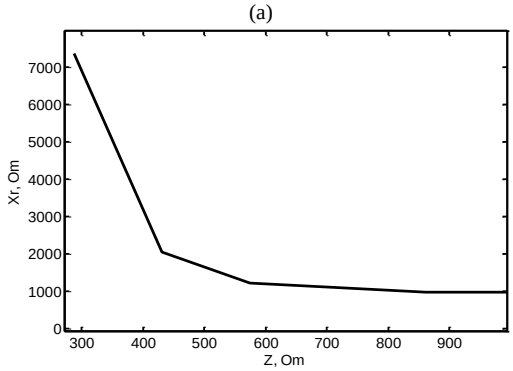


Figure 4. Random curve of Z linguistic change

The capacity of reactor (inductive reactance) is provided in the range of reactive power fuzzy demand. In other words, it can provid the burden of the proposed algorithm based on fuzzy reactor Q_r=min÷max in an effective change management through implementation in accordance with the operating voltage which does not change the nominal value of the tire (Figure 5).



(a)



(b)

Figure 5. Managing fuzzy curve: (a) reactive power and (b) inductive reactance

Figure 6 shows changing the voltage curves was shown in connection of TL by 500 kV to tire-covers at load resistance changes of Azerbaijan energy system.

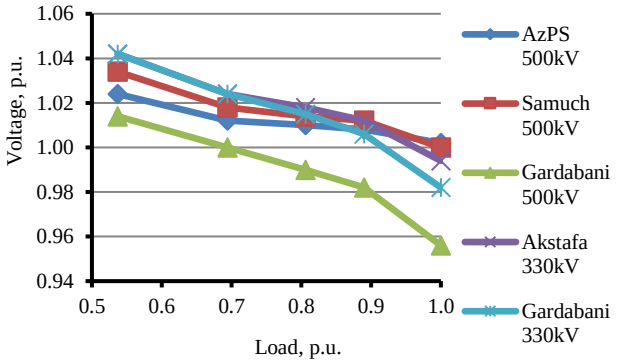


Figure 6. Changing the voltage curves without LR

As can be seen, depending on the load line voltage, the fluctuations can be allowable limits. Figure 7 shows LR fuzzy algorithm in the management of the above-mentioned change in the voltage curves are given.

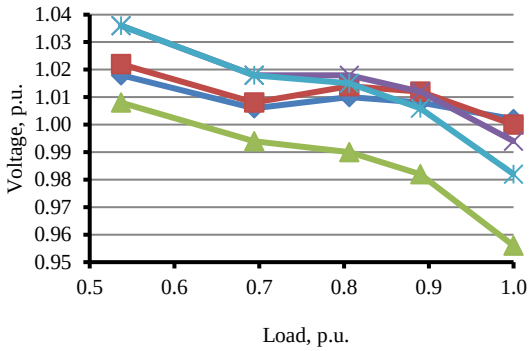


Figure 7. Fuzzy-driven changes in the voltage curves in LR

As shown in Figure 7, the reactor joining LR of tire tensions varies within the boundaries of the norm in prices and quality.

V. CONCLUSIONS

Extreme high-voltage power lines are connected to the fuzzy controller for shunt synthesis reactor inductivity problems have been solved. Depending on the load line of resistance and inductive reactance of the power control algorithm reactor is given. Computer modeling results compared with traditional management confirms the effectiveness of the proposed fuzzy algorithm. The reactor is operated on the basis of fuzzy controller works reliably and has a useful life of more.

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BIOGRAPHIES

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