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CENTER FOR INTERNATIONAL SCIENTIFIC PUBLICATIONS
JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN(Online): 2984-6722
SJIF Impact Factor | (2024): 6.752 |
Volume-8, Issue-5, Published | 20-05-2025 |

MODELING AUTOMATIC REACTIVE POWER CONTROL IN INDUSTRIAL ENTERPRISES USING THE FUZZY LOGIC METHOD

https://doi.org/10.5281/zenodo.15448402

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Abstract

In the article industry in enterprises reactive power automatic management fuzzy logic for model proposal based on The model voltage (ΔU) and reactive power (ΔQ) changes into account take , condenser batteries connect or to separate is managed by . Membership functions triangle in the form of identified , Mamdani inference and weight center methods through exit signal This approach is defined as in the system there is uncertainties into account take , control reliability increases . Offer done system electricity from energy effective use , energy saving and electricity of devices stable performance to provide service does .

Keywords

Fuzzy logic, reactive power, automatic control, voltage relay, membership function, Mamdani inference, defuzzification, capacitor bank, energy efficiency.

Currently, the automatic reactive power control system in industrial enterprises is implemented through voltage relays. The main task of this system is to ensure that the voltage and reactive power parameters in the electrical network are maintained within the normative and technically specified ranges. In this case, the system automatically adjusts the reactive power and makes optimal control decisions, depending on changes in network loads and the dynamics of energy consumption. In particular, when there is a risk of voltage or reactive power indicators deviating from the normative level, the system automatically determines the most optimal decision to start the necessary capacitor banks or disconnect them from the network. This approach makes it possible to increase the reliability of the electrical network, improve energy efficiency, rational use of energy resources, and ensure long-term stable operation of electrical equipment [1,2,3].

Specifying the input and output parameters of fuzzy control: The following input and output parameters are selected for the system . Input parameters of the following consists of [4,5,6].

U — voltage change in the network , (Δ U %)

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Q — reactive power change , (Δ Q %)

Exit parameters following indicated consists of [8,9].

C— connection/disconnection level of capacitor banks (from 0 to 100% was management signal .

Login parameters Fuzzy sets for determination following in stages done is increased . Login parameters fuzzy sets by is determined and their membership Membership function is defined .

Tension change (U): {"Low", "Normal", "High"}

Reactive power change (Q): {« Low », « Normal », « High » }

This membership functions triangle or trapezium in the form of is taken . Voltage for triangle membership function as follows is formed [7,10,11].

$$\mu_{low}(U) = \begin{Bmatrix} 1, & U \le -5\% \\ \dfrac{0-U}{5}, & -5 < U < 0\% \\ 0, & U \ge 0\% \end{Bmatrix}$$

$$\mu_{normal}(U) = \begin{Bmatrix} \frac{U+5}{5}, & -5\% < U < 0\% \\ \frac{5-U}{5}, & 0\% < U < 5\% \\ 0, & |U| \ge 5\% \end{Bmatrix} \quad (1)$$

$$\mu_{higt}(U) = \begin{Bmatrix} 0, & U \le 0\% \\ \dfrac{U}{5}, & 0\% < U < 5\% \\ 1, & U \ge 5\% \end{Bmatrix}$$

In this way , every one parameter for membership functions is determined .

Low (K), Normal (M), High (Kp)

Exit parameter Fuzzy sets for capacitors . batteries connect / disconnect fuzzy sets for level (C) following in appearance is determined [12,13].

{« Separation » ("A"), « O'immutable » ("O'"), « Union » ("U")}

Exit parameter membership the function is the same suitable accordingly triangle or trapezium in the form of is selected [14,15].

Fuzzy rules base (If-Then Rules). Fuzzy control system main fuzzy rules for part base organization Rules complex in the form of Table 1 is expressed .

Table 1

No.	Voltage (U)	Reactive power (Q)	Battery status (C)
1.	Low	Less	Connecting
2.	Low	Normative	Connecting
3.	Low	Many	Unchangeable
4.	Normal	Less	Connecting
5.	Normal	Normative	Unchangeable
6.	Normal	Many	Separation
7.	High	Less	Unchangeable

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8.	High	Normative	Separation
9.	High	Many	Separation

Fuzzy logic model mathematician formula . First entrance parameters according to fuzzification in the process membership functions values is found [16,17].

$$\mu_U(u),\ \mu_Q(q) \qquad (2)$$

Then and inference in the process rules to the base appeal will be done and of the results general fuzzy set is found . From the rule general fuzzy set transition Mamdani Inference method through done is increased [18,19].

$$\mu_C(c) = \max_i[min(\mu_U^i(u), \mu_Q^i(q))] \qquad (3)$$

In this i — every one activated rule .

Defuzzification in the process and the resulting fuzzy set clear management to the signal convert for weight center Centroid method is used [20].

$$C^* = \frac{\int c \cdot \mu_C(c)dc}{\int \mu_C(c)dc} \qquad (4)$$

Here * - capacitor batteries connection / disconnection clear management level (%).

Final Fuzzy Logic management in the algorithm and fuzzy control system generalized algorithm following in sequence done increased . initially system for necessary was all entrance variables measured and to the system is transmitted . This measured clear values next in stages fuzzification from the process is held , that is every one variable for in advance designated membership functions using their fuzzy sets affiliation degrees is determined . Next in stages of the system in advance formulated fuzzy rules to the base appeal activated to the rules appropriate entrance to variables related was exit fuzzy set of parameter This is formed . process inference from data using conclusion Inference in the process formed resultant fuzzy set system by done increase need was clear the decision designation for defuzzification from the stage At this stage , a fuzzy from the result only clear management signal (digital value) is taken . Therefore based on system last in stages exit to the parameters relevant was management practices does . Such wide comprehensive approach of the system uncertainty and variability level high was effective and precise in all situations and optimal decisions acceptance to do opportunity creates [21].

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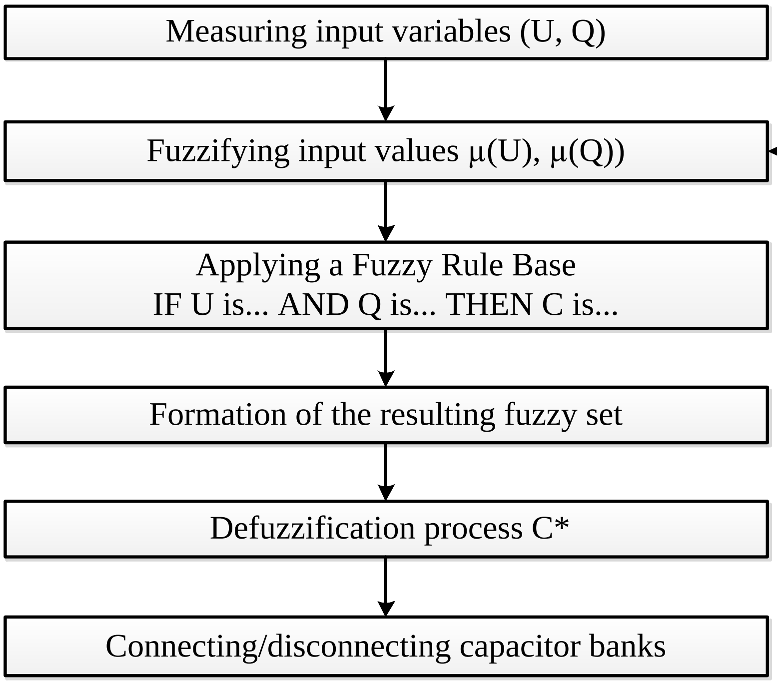

Figure 1. Algorithm for automatic control of reactive power at industrial enterprises based on fuzzy logic

The above-described mathematical model and fuzzy logic-based approach allow to ensure high efficiency and optimality in the automatic control of reactive power processes in industrial enterprises. The main advantages of fuzzy logic are manifested in taking into account the uncertainty present in the system and processes that are difficult to accurately represent mathematically. In particular, the application of fuzzy logic in the reactive power control system through voltage relays leads to faster and more accurate adaptation to the dynamic state of the system, an increase in the quality of control decisions and system stability [22].

This approach is also important in making decisions about the optimal connection or disconnection of capacitor banks. Traditional control systems often cannot adapt to sudden changes or may not work as effectively as necessary in processes with a high level of uncertainty. However, the fuzzy logic model optimizes the decision-making process in accordance with each change in the system, while ensuring that the voltage in the power grid is maintained at a standard level and creating conditions for the efficient operation of electrical equipment [23].

Another important aspect of systems developed using fuzzy logic is their multidimensional, that is, the ability to make decisions taking into account the influence of several parameters at the same time. The introduction of such systems also improves the economic efficiency of the reactive automatic power control process, increases the possibility of economical use of energy resources, and extends the service life of electrical devices [24].

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Conclusion: An approach based on fuzzy logic in the process of automatic control of reactive power in industrial enterprises provides high efficiency and reliability. Proposal fuzzy logic model voltage and reactive in power to changes adapted without condenser Optimal battery management opportunity This model is ambiguous . and dynamic in cases clear decisions acceptance to do, energy from resources reasonable use , electricity networks stability increase and electricity of equipment work the deadline extension opportunity creates . Therefore, fuzzy logic based management systems modern industry in enterprises reactive power effective management promising solution as recommendation is being done.

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