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MODE AND COMPENSATION OF REACTIVE POWER IN DISTRIBUTED NETWORKS BASED ON RENEWABLE ENERGY SOURCES WITH DISTORTING LOADS

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In most cases, electrical network loads use cosine capacitor compensators to compensate for reactive power. In this case, the required value of the compensating capacitance is determined from the condition for compensating for the phase shift between the main harmonics of the voltage and the point. The value of the power factor corresponding to this value of the phase shift is effective for the case of non-distorting and unchanging system modes. In the case of distorting systems and the integration of RES, such a power factor can lead to unsustainable power consumption patterns. Since in a network with RES and for a large number of modern consumers in higher harmonic modes, the power factor is less than , defined as the phase angle of the first harmonic. In this regard, at present, according to international standards, stringent requirements are imposed on the level of reactive power. For this purpose, the range of the harmonic composition of current and voltage has been expanded up to the 40th harmonic. To take into account this factor, an integral indicator of the harmonic composition of voltage and current is taken

$$K_{THD,U} = \sqrt{\sum_{n=2}^{40} U_n^2 / U_1} \qquad K_{THD,I} = \sqrt{\sum_{n=2}^{40} I_n^2 / I_1}$$

Some settings cause both unbalance and higher harmonics at the same time. Such installations include, for example, powerful arc furnaces, AC electric locomotives with valve installations.

The presence of asymmetric sources of higher harmonics leads to the emergence of asymmetric systems of currents and voltages of different frequencies:

$$U_n = \begin{bmatrix} U_{1,n,j} \\ U_{2,n,j} \\ U_{0,n,j} \end{bmatrix} \qquad I_n = \begin{bmatrix} I_{1,n,i} \\ I_{2,n,i} \\ I_{0,n,i} \end{bmatrix}$$

METHOD FOR DETERMINING THE RATIONAL POWER OF COMPENSATING DEVICES IN A DISTRIBUTED NETWORK BASED ON RES.

$$P = P_1 + \Delta P_L + \Delta P_H$$

$$\lambda = \frac{P}{S} = \frac{P_1}{S} + \frac{\Delta P_H}{S} + \frac{\Delta P_\Gamma}{S} = \lambda_C + \lambda_H + \lambda_\Gamma$$

$$S = \sqrt{\left(P_1 + P_H + \sum_{n=2}^{n_m} P_n\right)^2 + \left(Q_1 + P_H + \sum_{n=2}^{n_m} Q_n\right)^2}$$

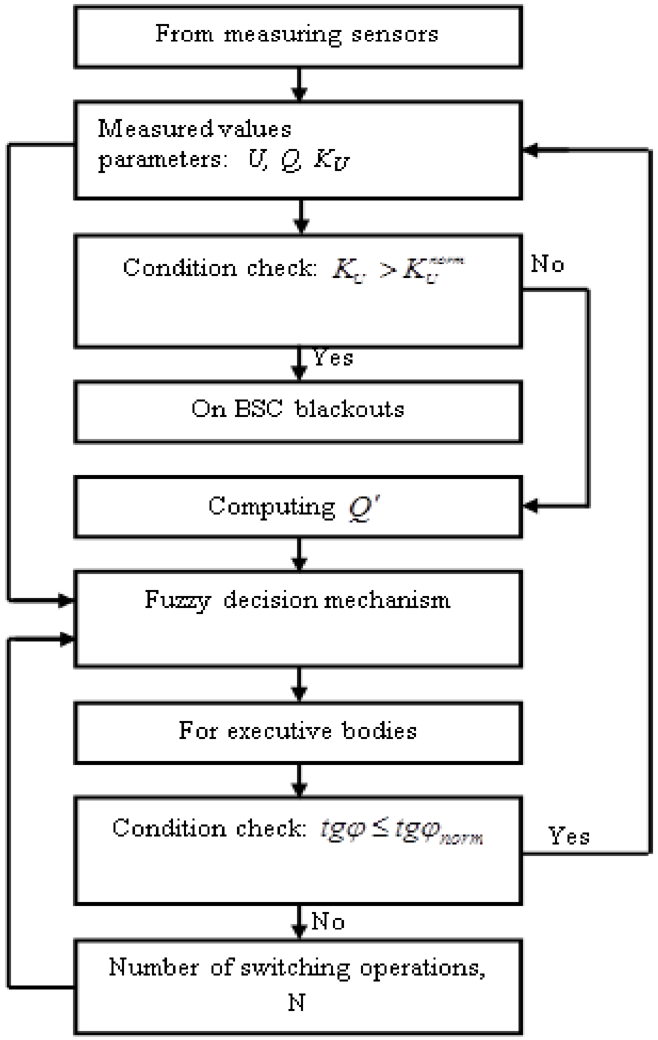
$$Q_1 = 3U_{11} I_{11} \sin \varphi_{11}$$

$$C_H = Q_1 / \left(3U_\phi^2 \omega\right)$$

$$I_C = \sqrt{\sum_{n=1}^{40} I_{c,n}^2} \leq 1{,}3 \cdot I_{nom,k}$$

$$U_C = \sqrt{\sum_{n=1}^{40} U_{c,n}^2} \leq 1{,}3 \cdot U_{nom,k}$$

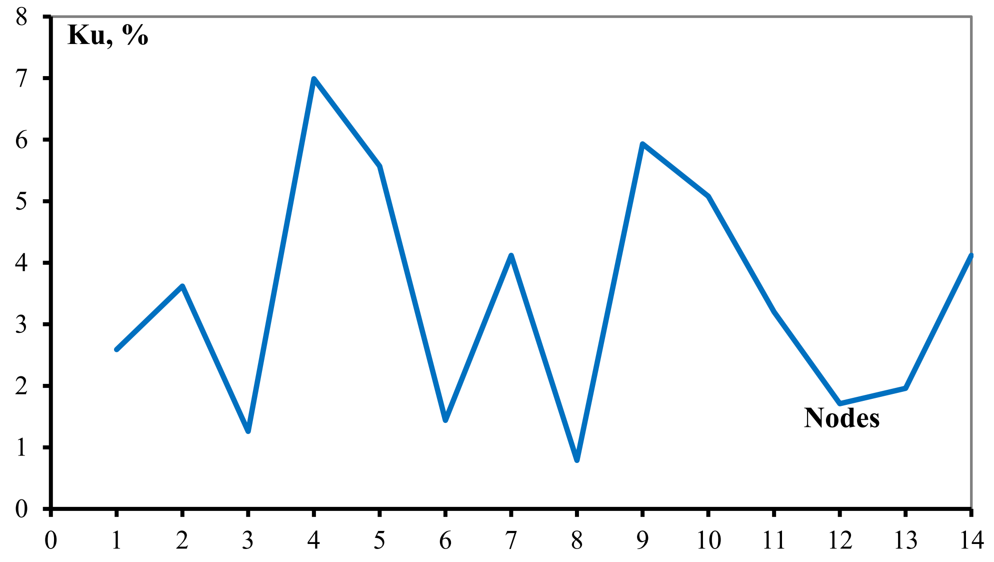
CONTROL ALGORITHM FOR REACTIVE POWER COMPENSATION IN A DISTRIBUTED NETWORK BASED ON RES AND WITH DISTORTING LOADS

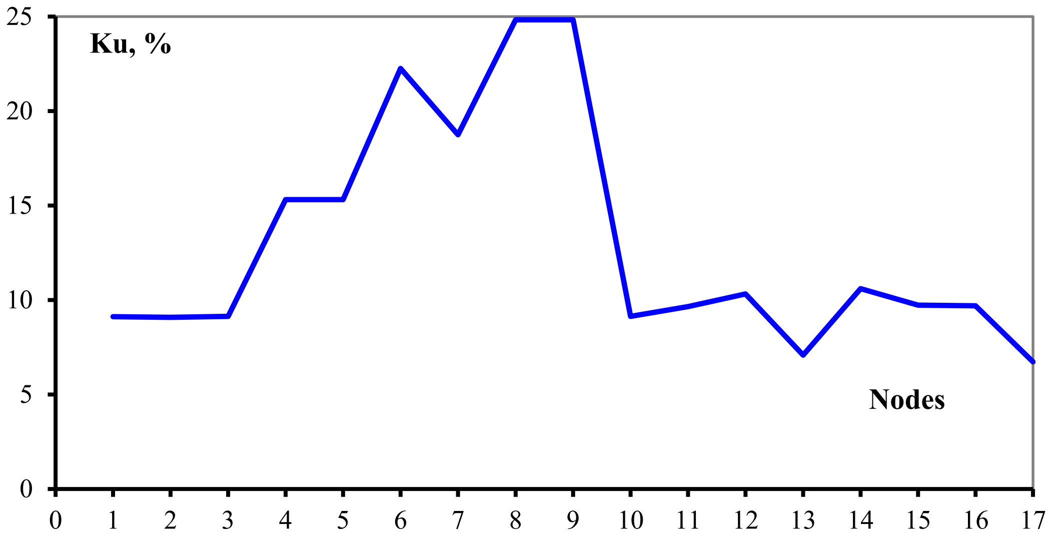


$$
\left.\begin{array}{l}
if\ x_1\ is\ A_{11},\ \ldots,\ and\ x_n\ is\ A_{1n}\ then\ y\ is\ .B_1 \\
f\ x_1\ is\ A_{21},\ \ldots,\ and\ x_n\ is\ A_{2n}\ then\ y\ is\ .B_2 \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
f\ x_1\ is\ A_{n1},\ \ldots,\ and\ x_n\ is\ A_{mn}\ then\ y\ is\ .B_m
\end{array}\right\}
$$

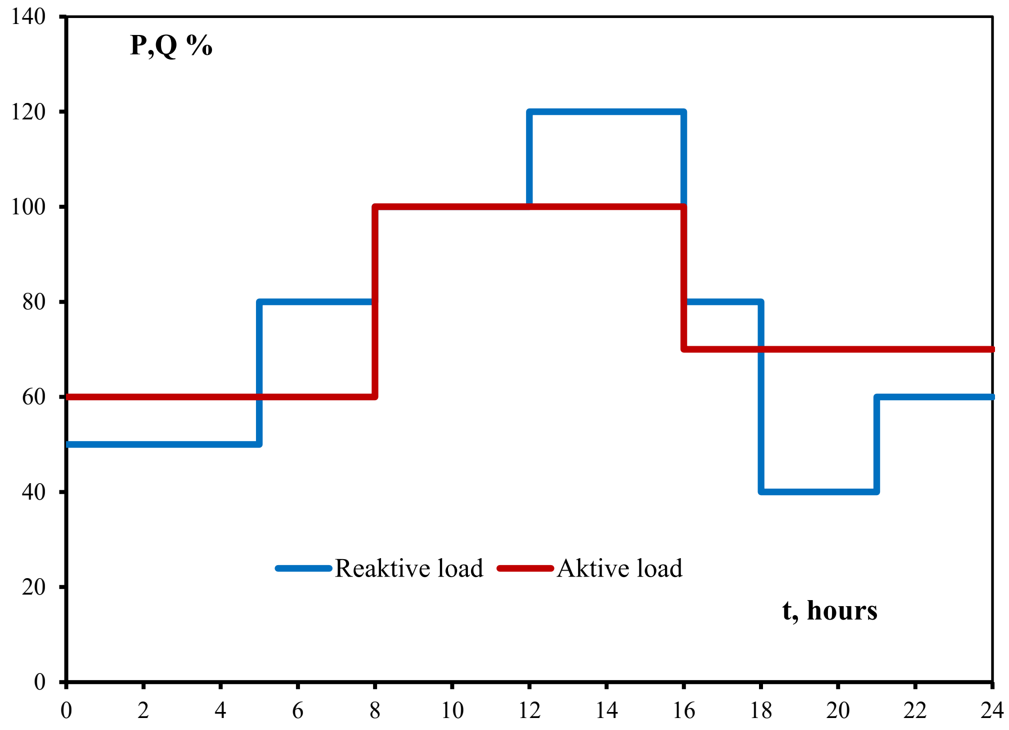
Terms	Membership function	Numerical values of term parameters
Reactive power		
Very small	Z–figurative	(0 0.045)
Small	Trapezoidal	(0 0.045 0.145 0.22)
Medium	Trapezoidal	(0.145 0.22 0.42 0.46)
Big	Trapezoidal	(0.42 0.46 0.86 0.97)
Very big	S- figurative	(0.82 0.93 1.0)
Dynamics		
Negative	Z- figurative	(-0.45 0)
Zero	Triangular	(-0.82 0 0.82)
Pozitive	S- figurative	(0 0.45)
Voltage		
Low	Trapezoidal	(0.7 0.75 0.9 0.96)
Normal	Trapezoidal	(0.9 0.95 1.05 1.12)
High	S- figurative	(1.06 1.12)
Emergency	Z- figurative	(0.9 0.75)
Harmonic distortion		
Normal	Z- figurative	(2.6 6.1)
Little big	Triangular	(2.6 6.1 9.2)
Big	S- figurative	(6.1 9.2)
Quantity		
Small	Z- figurative	(0 8 11)
Not Small	S- figurative	(8 11 13)
Directions		
Up	Trapezoidal	(0.5 0.75 1.25 1.5)
Down	Trapezoidal	(-1.5 -1.25 -0.75 -0.5)
Stop	Trapezoidal	(-0.5 -0.25 0.25 0.5)
Delay		
Very Small	Z- figurative	(0 0.045)
Short	Trapezoidal	(0 0.045 0.16 0.22)
Medium	Trapezoidal	(0.16 0.22 0.42 0.47)
Long	Trapezoidal	(0.42 0.47 0.86 0.96)
Very long	S- figurative	(0.82 0.92 1.12)

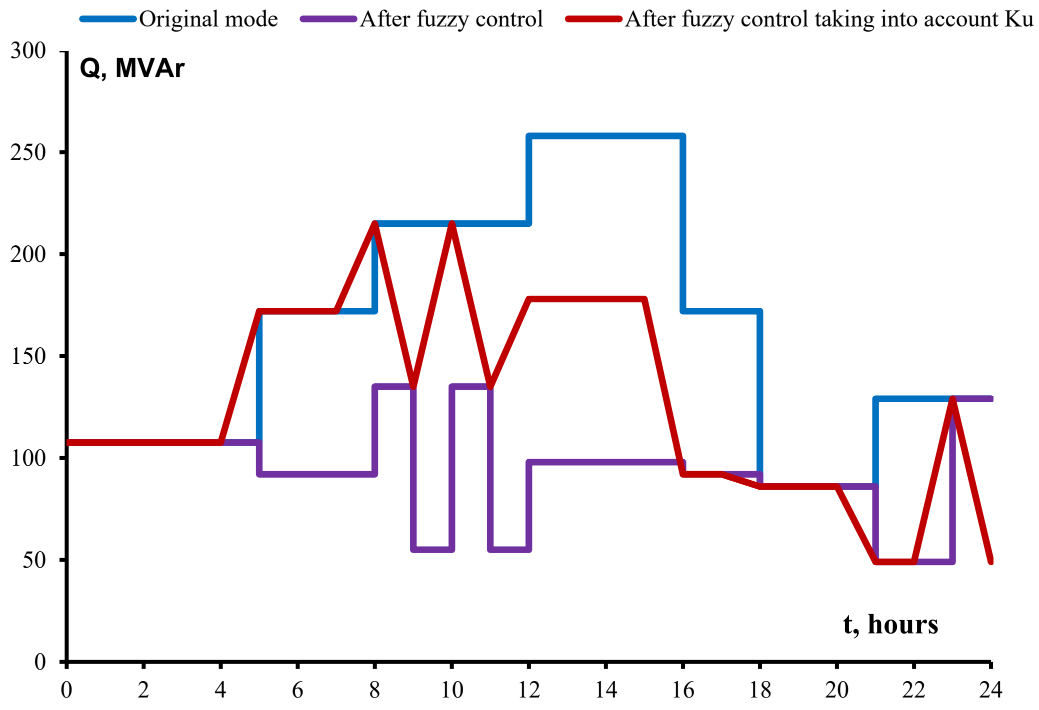
RESULTS OF THE STUDY OF HIGHER VOLTAGE HARMONICS ACCORDING TO THE SCHEMES OF IEEE AND AZERENERGY WITH INTEGRATED RES





RESULTS OF SIMULATION OF THE FC CONTROL ALGORITHM





CONCLUSION

1. The method of rational choice of compensators for compensating reactive power under RES conditions and uncertain circuit-mode changes in the distributed generation system based on RES, asymmetry and non-sinusoidality created by distorting loads is given. The method makes it possible to take into account the effect of asymmetric higher harmonics of currents on the SCB.

2.In a distributed generation system based on the IEEE standard 14-node scheme and the real Azerenerji network scheme with integrated RES, the values and changes in the coefficient of the n-th harmonic components and the total coefficient of harmonic components for current and voltage were determined. In the case under consideration, it was found that the values of some harmonic components and the total coefficient of the harmonic component of the voltage exceed the established standards, which must be taken into account when compensating for reactive power.

3. Based on the fuzzy logic model, an algorithm FC of reactive power in a system with distributed generation based on RES with distorting loads is proposed, which allows stabilizing the variability of the reactive power factor within the limits established by the operating conditions for consumers, as well as to ensure the normal operational technical condition of the SCB. As a result of taking into account the harmonic distortion of sinusoidal voltage and current in the algorithm, overloads of the SCB with higher harmonic currents are prevented. This leads to an increase in the functional reliability of switching devices, as well as SCB as a whole.