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EFFECT OF POWER QUALITY ON THE PERFORMANCE OF EXPLOSION-PROOF TRANSFORMERS IN MINING IN VIETNAM

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Introduction

When meeting customer demand, utility companies must consider power quality. Currently, the industrial power network in general and the underground mine power network in particular have long feeder lines, supplying power to many nonlinear loads and power electronic converters, which reduces power quality. Poor power quality can damage sensitive equipment and lead to costly repairs, leading to lost time, data corruption, and lower productivity. In this paper, a fuzzy system is developed to determine the power quality of the power network for different operating conditions and study its influence on the performance of the explosion-proof transformer in the underground mine power network in Vietnam. The simulations and calculations were performed on Matlab-Simulink software for a three-phase, 630-kVA, 6/1.2 kV explosion-proof transformer in power networks with variable power quality. A fuzzy system is developed with four measurable inputs, including frequency deviation, voltage unbalance factor, total harmonic distortion of supply voltage, total harmonic distortion of current, and an output variable, power quality.

Table 1.
Power quality of Vietnam's distribution power system.

Voltage lever	Voltage unbalance	Voltage THD, THDu	Current THD, THDi	Frequency
01 kV to 35 kV	± 05%;	5%	8%	50 Hz ± 0.2 Hz

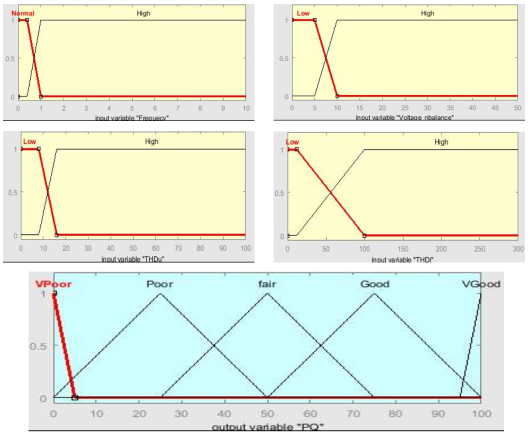

Fig. 1. The fuzzy membership functions used for (a) frequency deviation (b) voltage unbalance, (c) voltage THD, (d) current THD, and (e) power quality

A fuzzy system for determination of power quality

The article builds fuzzy systems on the MATLAB fuzzy logic toolbox; it includes membership functions and fuzzy rules. Where the membership functions of frequency deviation (b) voltage unbalance, (c) voltage total harmonic distortion (THDu), and (d) current total harmonic distortion (THDi) are determined by 2 states: Low and high, corresponding to the values shown in Table 1, The measurement of the output variable power quality is expressed as membership functions such as very good, good, fair, poor, and very poor. The configuration of membership functions is shown in Figure 1. The power quality detection system in fuzzy logic uses the Mamdani fuzzy system. Fuzzy rules are shown in Figure 2.

Research results and discussion

With the characteristics of the underground mine power grid, the study conducts simulation tests with three typical cases of voltage quality: power quality is very good; power quality is good; and power quality is fair. The case power quality is very good, corresponding to the values within the allowable range in Table 1.

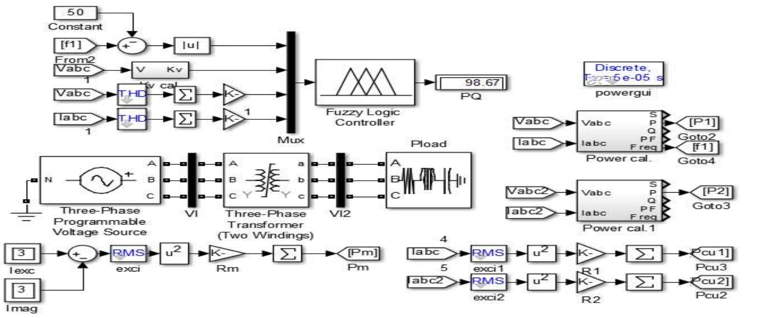

Fig. 3. Simulation model for a three-phase explosion-proof transformer

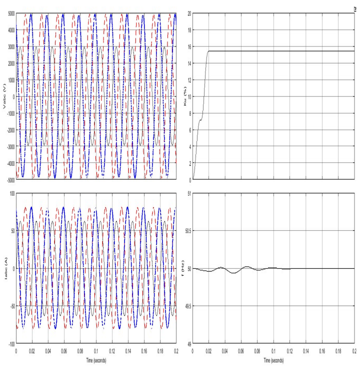

Fig. 4. The case of good power quality

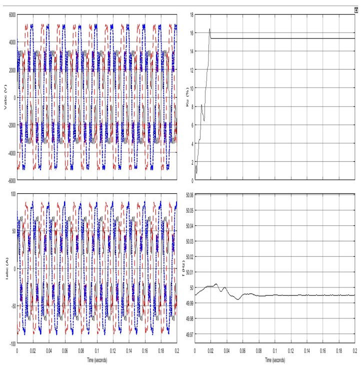

Fig. 5. The case of fair power quality.

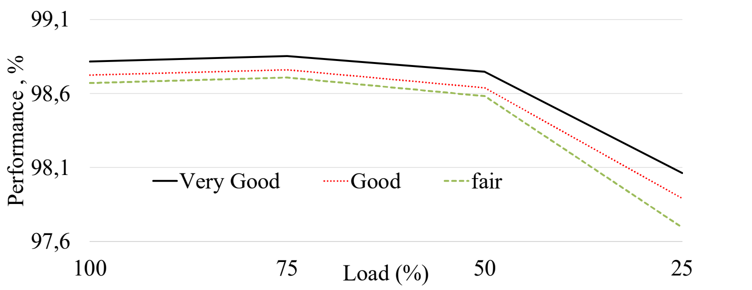

Fig. 6. Dependence of transformer performance on load in case of power quality.

Figure 6 depicts the dependence of transformer performance on load in case of power quality. Obviously, when the voltage quality is "very good", the performance of the explosion-proof transformer is highest. As power quality deteriorates, the performance of explosion-proof transformer gradually decreases. This result is similar to the results presented experimentally in the study [5]. In any case, transformer performance is maximized with a load of about 75% of the manufactured power, then the performance will decrease as the load decreases. It is also clear from the diagram that when the load is less than 50% of the capacity of the transformer, the bad voltage quality will reduce the performance significantly.

Conclusions. This paper focuses on building a method to determine power quality through fuzzy systems and building a model to evaluate the performance of explosion-proof transformers in underground mine power grids in Vietnam under different power quality conditions. The results show that the fuzzy system clearly identifies the power quality parameters with four measurable inputs, including frequency offset, voltage unbalance factor, voltage total harmonic distortion, and current total harmonic distortion. Simulation results show that explosion-proof transformer performance decreases when power quality degrades, and the proposed fuzzy system can accurately diagnose this. When the load is less than 50% of the transformer power, the poor power quality will reduce the performance significantly. The results clarify the importance of power quality to the consuming equipment, thereby requiring solutions to improve the power quality of the power system, especially the underground mine power grid system.