

COMPENSATION OF REACTIVE POWER IN AUTONOMOUS ELECTRIC POWER SOURCES

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Annotation. This article analyzes the issue of reactive power that arises during the operation of diesel generators and methods for its compensation. Based on modeling, the interaction between the generator, battery, and converter device under various load conditions has been studied. The research results enable effective limitation of the generator’s output power and improvement of system efficiency through reactive power compensation. Based on the findings, technological proposals and recommendations for energy saving are provided.

Keywords: diesel generator, reactive power, active power, converter device, electrical energy efficiency, compensation.

1. Introduction.

Nowadays, diesel generators are widely used in various sectors as an important source of independent power supply. Their role is especially invaluable in facilities disconnected from the power grid or located in remote areas. However, during the operation of these generators, the issue of reactive power arises. Although reactive power does not perform useful work, it causes fluctuations in current and voltage within the electrical system, placing additional load on the generator and other equipment. As a result, the overall efficiency of the system decreases, and energy losses increase. The aim of this article is to explore methods for compensating reactive power in diesel generators and to propose effective solutions[1].

2. Methods (Metodlar).

In this study, power fluctuations and reactive power compensation occurring during the operation mode of diesel generators were modeled. During the modeling process, the active and reactive power components were analyzed for loads with $\cos\varphi = 0.8$ and $\cos\varphi = 0$. The interaction between the power source, converter, and battery was observed through time-based diagrams. The calculation results were compared with the modeling outcomes in Tables 1, 2, and 3. Variations in current and voltage, pulsating components, and modulation coefficients were considered as key parameters[2].

Parameter	Calculation	Modelling	Deviation, %
$K_{GI} (f_s), \%$	6,00	6,14	2,3
$S_I (M_{max.cal.}), \text{kVA}$	100,0	96,4	3,6
$M(SI_{max.cal.})$	0,990	0,991	0,1
P_{Gmin}, kVt	30,0	30,0	0
P_{Gmax}, kVt	80,0	80,0	0

Table 1. Comparison of calculated and measured parameters in the generator active power limiting mode.

Parameter	Calculation	Modelling	Deviation, %
$K_{GI} (f_s), \%$	6,00	5,85	2,5
$S_I (M_{max.cal.}), \text{kVA}$	100,0	99,2	0,8
$M(SI_{max.cal.})$	0,990	0,991	0,1
P_{Gmin}, kVt	40,0	40,0	0
Q_{Gmax}, kVA	30,0	30,0	0

Table 2. Comparison of calculated and measured parameters in the generator active-reactive power limiting mode.

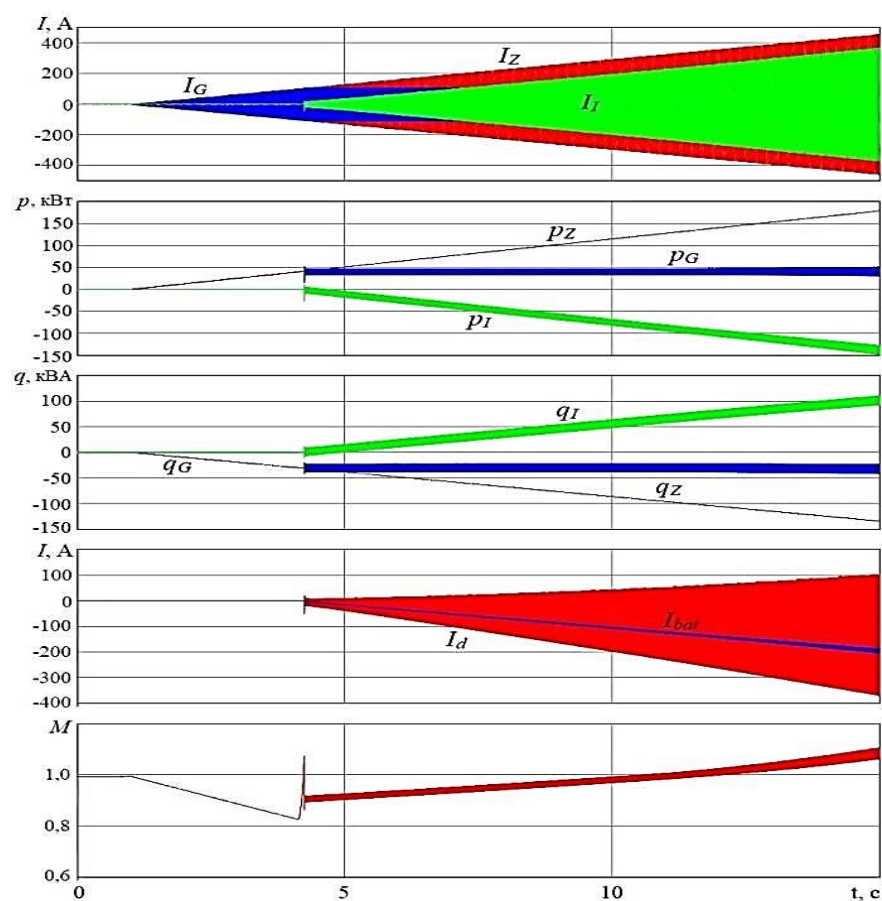


Figure 1. Modeling results of the power supply system in the generator active-reactive output power limiting mode.

Parameter	Calculation	Modelling	Deviation, %
$K_{GI} (f_s), \%$	6,00	5,80	3,3
$S_I (M_{max.cal.}), \text{kVA}$	100,0	99,4	0,6
$M(SI_{max.cal.})$	0,990	0,991	0,1
Q_{DGmax}, kVA	30,0	30,0	0

Table 3. Comparison of calculated and measured parameters in the generator reactive power limiting mode.

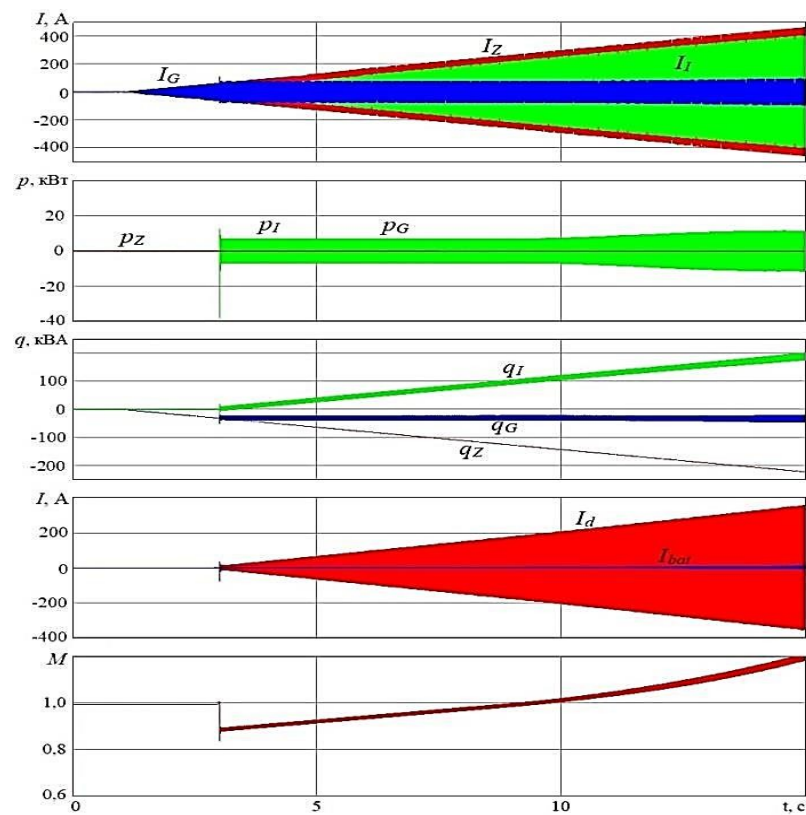
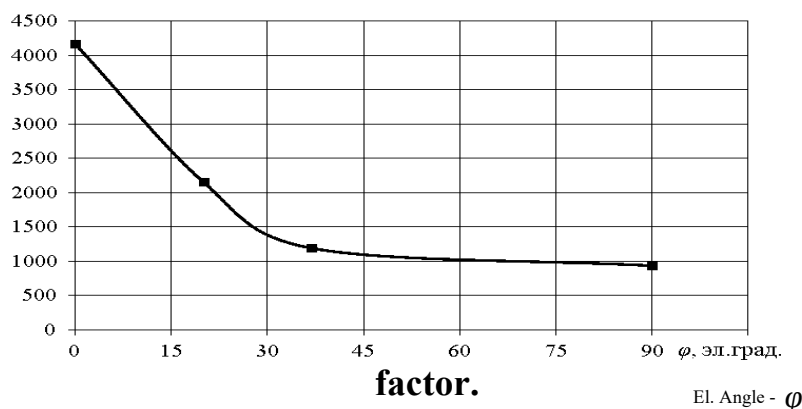


Figure 2. Modeling results of the power supply system in the generator reactive output power limiting mode.

3. Results.

Starting from 0.35 seconds, the active power of the load begins to increase linearly. Until 2.13 seconds, the output power is maintained around 30 ± 7.2 kW. At 5.35 seconds, when the load power reaches the upper limit, the battery is activated. The comparisons in Table 1 show that the modeling results are close to the calculations with a maximum error of 3.6%. The range of the modulation coefficient relative to the $\cos\varphi$ values was determined, and the sensitivity of the power regulator was evaluated graphically through Figure 3[3].

Figure 3. Influence of the power regulator's sensitivity on the load power



4. Discussion.

The research shows that reactive power compensation using a converter device allows the diesel generator to produce only active power. This reduces its overall load and increases energy efficiency. The control system, developed based on the model, supports the reactive component with the help of a battery, which stabilizes the electric field in the system. By minimizing amplitude and changing the current phase, it became possible to limit the amount of reactive power. Additionally, the obtained results demonstrated new opportunities for improving energy savings[4,5].

5. Conclusion.

The experimental results show that increasing system efficiency is possible through reactive power compensation in diesel generators. The minimal difference between model results and actual calculations indicates that this method can be practically implemented.

Recommendations:

- Implementation of reactive power compensation systems in generators,
- Development of mechanisms to control active and reactive power using batteries and converters,
- Designing a control system based on phase analysis and signal modulation to improve electrical energy efficiency is advisable.

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