REVIEW

on a dissertation for the acquisition of an PhD degree in the field of higher education 5. "Technical Sciences", Professional field 5.2. "Electrical Engineering, Electronics and Automation", doctoral program "Elements and devices of automation and computing technology" .

Author of the dissertation: **Dipl.Eng . Petar Ivanov Petrov**

Topic of the dissertation: **"Influence of load on reactive power in asymmetric and non-sinusoidal modes"**

Reviewer: **Prof. Dr. Siya Valcheva Lozanova, IR-BAS**
member of the scientific jury, according to order No. 78/16.07.2025 of the Director of the Institute of Robotics at Bulgarian Academy of Sciences

1. PhD student data

Dipl. Eng. Petar Petrov completed his higher education with a Master's degree in Electronic Engineering at the Russe University "Angel Kanchev". He is enrolled in an open doctoral study in the program "Elements and Devices of Automation and Computing technology", professional field 5.2 Electrical Engineering, Electronics and Automation in the " Robotics in Energy " department at the Institute of Robotics - Bulgarian Academy of Sciences. Since 2024 until now, he is an assistant in the same department.

Assistant Petar Petrov has fulfilled all the requirements of the individual plan of his doctoral studies and has successfully passed all the necessary exams.

The procedure for the public defense of his dissertation was launched at the proposal of the "Robotics in Energy" section and by decision of the Scientific Council of the Institute of Robotics-BAS.

According to the "Report on the fulfillment of the minimum requirements for a PhD in the relevant scientific field" submitted by the candidate, in accordance with the requirements of the Bulgarian Academy of Sciences, it is evident that he has 216 points with a required minimum of 200 points. Therefore, the scientometric requirements for the "PhD" degree are met.

2. Relevance of the dissertation work, problem

The dissertation considers the main conventional and high-tech methods for compensation of reactive loads in industrial facilities. The consumption of reactive power characterizes the load on the elements of the power supply systems (PSS), associated with the inactive nature of consumers, in which there is no useful transformation of one type of energy into another. Compensating systems have a direct impact on the quality indicators of electrical energy (EE). Control of reactive power flows and, in particular, compensation of reactive loads is a basic method for saving EE and achieving high-quality and reliable electricity supply. The author has critically examined classical and modern theoretical approaches to the study and analysis of methods for compensation of reactive loads. Methodological guidelines for calculating and synthesizing circuit designs for the application of passive and active filter-compensating devices are discussed. The presented statements aim to characterize and clarify the positive aspects and disadvantages of applying more complex and non-specific approaches to reactive load compensation (RFC) in the existing wide variety of consumers in the ESS. Experimental studies on reactive load compensation under nonlinear and asymmetrical loading in real facilities are presented. Based on existing developments, a methodology for the research process in RFC is proposed using the criteria "Electric power efficiency". A practical application for optimizing RFC using capacitor banks, chokes and synchronous motors is shown. An approach to RFC is described by controlling the compensating powers using the criterion "Direction and magnitude of reactive power", applying anti-resonance protection, implementing sequential active filters and building SCADA for monitoring, control and management of power processes. The methodology shows high technical and economic efficiency. All of this, in my opinion, motivates the relevance of the dissertation topic and its practical focus.

3. Level of knowledge of the state of the problem and critical aspects of the literature material

The dissertation narrative shows the good literature awareness of the PhD student. The bibliography cites 129 literary sources, of which 45 are in Latin. Based on both the first chapter and the remaining three chapters of the dissertation, in which results are presented and discussed, it can be concluded that Dipl.Eng. Petar Petrov is very familiar with the issues under consideration. Based on a critical assessment of the literature on the topic, the doctoral student thoroughly analyzes the existing problems. The following main goal of the study is formulated: To analyze the processes of compensation of reactive loads in nonlinear modes depending on the load by applying innovative computational and technological methods.

To achieve this goal, the following logically related tasks have been set :

1. To perform compensation of reactive loads and interpret their operational characteristics, applying high-tech solutions for compensation of reactive loads with applicability in industrial sites;

2. To synthesize new theoretical propositions for the study, analysis and application of reactive load compensation methods with a practical focus;

3. To investigate the compensation of reactive loads under nonlinear and asymmetric loading using a synthesized methodology, tested in a suitable research site;

4. To optimize the compensation of reactive loads in a large industrial facility using synchronous motors and capacitor banks, by solving an optimization problem using the "Minimum of the reduced annual costs" criteria and to prove the electrical energy efficiency of the technological solution.

4. Compliance of the selected research methodology with the set goal and tasks of the dissertation

In accordance with the set goal and tasks, in the dissertation work, optimization of the MRT in the ESS of a powerful industrial facility has been carried out. For this purpose, an in-depth analysis of the circuit-technical features of the facility has been conducted, allowing for the creation of an adequate concept of the optimization process. The load analysis has been put through on a daily and monthly basis, and the characteristic coefficients for four significant units of the ESS have been determined.

The operation and parameters of the main facilities at the site - sources of reactive power (synchronous motors, power transformers, cable lines, asynchronous motors, capacitor banks) have been analyzed. A quantitative assessment of the generated reactive power has been made, and the active losses in the transfer of reactive energy have also been determined.

An optimization problem is defined using the criterion "Minimum of the reduced annual costs" and four restrictive conditions. The extremum of the objective function is determined using the Lagrange method.

The synthesized methodology for optimizing reactive powers is maximally adapted to the capabilities of the circuit-technical data of the site and is adjusted for the simultaneous use of SD and KB when conducting MRT.

5. Analytical characteristics of the dissertation work

The work is developed in a volume of 129 pages, containing 104 figures and 38 tables. Its structure includes an introduction, a list of symbols used, four chapters, general conclusions after each chapter, general conclusions of the work, contributions of the work, used literature and a list of publications.

The *first chapter* discusses conventional methods for compensation of reactive loads. The disadvantages of low cos φ are listed, which necessitates the implementation of measures to improve cos φ in the power supply system of industrial enterprises. These activities should be carried out in two directions - improving cos φ without compensating devices (natural methods) and improving cos φ with the help of compensating devices. The goal and objectives of the dissertation are formulated .

In *the second chapter* a theoretical framework has been developed to determine the effective values of some electrotechnical parameters related to reactive load compensation. A comprehensive approach to reactive load compensation methods in power supply systems of industrial facilities has been developed. An energy -based approach to assessing the deformation and unbalance of currents and voltages in power supply systems, related to compensation of reactive loads.

In *the third chapter,* they are examined compensation of reactive loads under nonlinear and asymmetrical loading in real objects. A methodology has been developed for the compensation of reactive loads according to the criterion "Electricity Efficiency". The defect coefficient of three-phase, loadable units has been determined in terms of power indicators in connection with the compensation of reactive loads.

In *the fourth chapter* the possibilities for optimizing the compensation of reactive loads using a synchronous motor and a capacitor bank have been analyzed. The load on the power supply system of the research site, as well as the medium voltage cable lines, has been determined.

6. Scientific and applied-scientific contributions of the dissertation work

In my opinion, the material contains a total of 2 scientific and 3 scientific - applied contributions. They can be summarized as: creating new methods and technologies, obtaining and proving new facts. My assessment of these results is as follows:

Scientific contributions:

1. An innovative theoretical statement has been formulated based on the criterion "Electricity efficiency" with the application of a differentiated approach

for determining the components of active losses from inactive power substances (N, S_o and D). A methodology has been tested in a power facility when studying the effectiveness of reactive load compensation (CRCC) .

2. A methodological statement has been synthesized for determining three-phase, power-weighted indicators, which with a high degree of adequacy, reliability and identity are used in calculating the power factor PF and in overload mode.

Scientific- applied contributions relate to:

3. Practical-applied settings for powerful popular consumers (electric arc furnaces, industrial electronic converters, rolling mills, third-class consumers in terms of electromagnetic compatibility) introducing significant disturbances into the power supply systems of industrial facilities are presented. The probability of occurrence of resonance phenomena in the process of their suppression is analyzed.

4. Equivalence has been established when implementing the different modes and load conditions. It has been established that the coefficient of additional losses in asymmetric and non-sinusoidal modes at reduced load is about 20% higher than that at normal load.

5. An optimization of the electricity consumption of a powerful industrial facility in the chemical industry was carried out according to the criterion "Minimum of the reduced annual costs" and a technical solution with synchronous motors and a capacitor bank was implemented. The solution was implemented at two levels – medium and low voltage. The optimization task makes it possible to determine the number and power of synchronous motors and to predict the extent to which the use of a capacitor bank is economically feasible.

7. Evaluation of the publications on the dissertation work

The results of the dissertation are contained in 5 publications. They were reported at the national conference "Energy Forum", Varna. One publication is single-authored, and the others are co-authored with his scientific supervisor.

It is obvious that the results of the dissertation work have become available to the scientific community.

8. Degree assessment for PhD student's personal participation in dissertation contributions

Based on the presented research and the authorship of the publications on the dissertation, I believe that it is an independent work of the PhD student, realized with the assistance of his supervisor.

9 . About the Review

The dissertation review fully and clearly reflects the main points of the content and contributions of the dissertation work. The requirements for preparing reviews for dissertation works have been met.

10. Opinions, recommendations and notes.

The dissertation is an extensive and well-structured scientific work on the researched issue . However, the conclusions are excessively long and often there is no precise and clear formulation of the achieved results. The scientific and applied results are not sufficiently well marked, although they are presented and argued in the dissertation. In addition, texts of some of the figure illustrations are missing, for example 1.6, 1.7, from 1.10 to 1.14, etc.

I recommend that the PhD student to continue his research in this area, which is important for practice and to have more single-authored publications.

11. Conclusion

The dissertation work of Dipl.Eng. Petar Ivanov Petrov contains analytical and simulation results, through which the tasks set have been solved. My overall assessment is positive. There are sufficient contributions that meet the requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria, the Regulations for its implementation and the Regulations for the Development of the Academic Staff at the IR-BAS, for awarding the educational and scientific "PhD" degree.

Based on the above, I propose to the Scientific Jury to award **Dipl.Eng. Petar Ivanov Petrov** educational and scientific "PhD" degree in the field of higher education 5. "Technical Sciences", professional field 5.2. "Electrical Engineering, Electronics and Automation", doctoral program "Elements and Devices of Automation and Computing technology".

15.09.2025.   Reviewer:.........
                                                      /Prof. Dr. Siya Lozanova /