# STATEMENT

**regarding the dissertation**
**for obtaining the educational and scientific degree "PhD" in**

**Field of higher education – 5 "Technical Sciences"**
**Professional field 5.1 "Mechanical Engineering"**
**Doctoral program – "Hydraulic and Pneumatic Drive Systems"**
**Author: M.Sc. Eng. Krasen Ivanov Kostov**
**Title: Intelligent Control of an Electrohydraulic Drive System**
**Member of the scientific jury:**
**Assoc. Prof. Dr. Eng. Kliment Velikov Klimentov**

## 1. Topic and relevance of the dissertation

Electrohydraulic drive systems occupy a key position in modern mechatronic applications, where high power, fast response and reliability are required. Their wide use in industrial automation, mobile hydraulics, robotics and transport technology imposes high demands on control quality. Classical control methods increasingly struggle to compensate for nonlinearities, hysteresis, variable loads and external disturbances typical of hydraulic systems, which necessitates new approaches.

In recent years, there has been a clear trend toward the implementation of intelligent algorithms – neural networks, fuzzy logic, adaptive and self-learning models – which enable improved accuracy, robustness and energy efficiency of electrohydraulic drives. These methods fully correspond to the concepts of Industry 4.0 and cyber-physical systems, where drives must operate in networked environments, exchange data in real time and respond adaptively to changes in operating conditions.

The relevance of the topic is determined by the need to develop intelligent control systems that ensure higher precision, reliability and optimization of energy consumption. This makes the topic significant both from a scientific point of view and for the practical development of modern mechatronic and hydraulic technologies.

## 2. Research methodology

The research methodology is built upon a sequential combination of theoretical analysis, mathematical modeling, simulation experiments and experimental verification of the electrohydraulic servo system. In the first stage, an in-depth analysis of the dynamic properties of electrohydraulic drives is performed, accounting for nonlinearities, hysteresis effects and parametric uncertainties characteristic of real operation. Based on this, a nonlinear and linearized mathematical model is developed, including the equations of motion of the hydraulic motor, flow characteristics through the valve and the dynamics of the control elements.

After linearization around an operating point, the model is transformed into an operator form, enabling the synthesis of block diagrams and transfer functions of the open and closed-loop system. A simulation model is built in MATLAB/Simulink, through which studies are conducted in near real-time modes. The simulations include analysis of transient processes under reference input and load disturbances, evaluation of the influence of PID parameters and determination of the stability region using the Routh–Hurwitz criterion.

The methodology also includes parametric identification implemented through the Levenberg–Marquardt algorithm (lsqnonlin function), minimizing an integral criterion for the closeness between experimental and simulation data. Identification is performed on real transient processes recorded from the laboratory test bench, determining key parameters such as gain, moment of inertia, viscous friction, leakage coefficients and effective volume.
In conclusion, the methodology integrates modeling – simulation – experiment, providing high model adequacy and a reliable basis for the synthesis of intelligent and robust controllers (Fuzzy, Fuzzy-PID, H∞), studied in subsequent stages.

**3. Contributions of the dissertation**
**Scientific-applied contributions**
1. A nonlinear and linearized mathematical model of an electrohydraulic servo system with a rotary actuator has been developed, accounting for real physical processes, dynamic dependencies, leakage, hysteresis and parametric uncertainties.
2. A methodology for parametric identification of electrohydraulic systems under different load conditions has been developed, based on optimization algorithms and experimental data.
3. Intelligent and robust control methods – Fuzzy, adaptive Fuzzy-PID and H∞ controllers – have been synthesized and adapted to the specifics of electrohydraulic systems.
**Applied contributions**
1. A hardware-software platform for real-time investigation of electrohydraulic servo systems integrated with MATLAB/Simulink has been created.
2. Models and algorithms applicable to the design, analysis and tuning of electrohydraulic systems in industrial and laboratory environments have been developed.
3. Experimental validation of the models under various load regimes has been performed, enabling practical application of the developed methods in engineering practice.

**4. Publications and citations related to the dissertation**
There are 7 publications related to the dissertation. Four of them are published in journals indexed in Scopus, two are published in peer-reviewed Bulgarian journals, and one is presented at a national scientific forum and is a single-author publication. According to Scopus, three of the publications have a total of 4 citations (excluding self-citations).
I consider that the publications sufficiently reflect the results of the dissertation.

**5. Authorship of the obtained results**
The published scientific works are developed in co-authorship, with the doctoral candidate contributing to the formulation of the tasks and participating in the theoretical analysis, development of models and control algorithms, conducting experimental studies, processing and interpreting results, preparing graphical materials and participating in the preparation of the articles.
The single-author publication from 2024 demonstrates the candidate's ability to conduct independent experimental research and present results in scientific form. All results included in the dissertation were obtained personally by the author or with his direct participation and are not borrowed from other studies.

**6. Opinions, recommendations and remarks on the dissertation**
I have no substantial remarks of a principal nature regarding the presented dissertation.

I believe that the dissertation presents results from a large volume of research work. In my opinion, the theoretical and experimental studies are conducted at a very high level, using modern methods and an advanced experimental test bench. I have no prior impressions of the candidate's work in the Department of "Energy Engineering", but based on the presented work, I am left with the impression that Eng. Kostov has significantly improved his qualifications in the field of control of electro-drive systems.

**7. Conclusion**

I consider that the presented dissertation meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria. The achieved results give me grounds to propose that the educational and scientific degree "PhD" be awarded to:
**M.Sc. Eng. Krasen Ivanov Kostov**
in the field of higher education – **5 "Technical Sciences"**,
professional field – **5.1 "Mechanical Engineering"**,
doctoral program – **"Hydraulic and Pneumatic Drive Systems"**.

10.08.2026 г.

**Signature:**
/Assoc. Prof. PhD. Kliment Klimentov/