

## REVIEW

*by Prof. Raicho Todorov Ilarionov, D.Sc.,  
Full Professor at Technical University of Gabrovo,  
Department of Computer Systems and Technologies*

*of the materials submitted for participation in a competition for the academic position "Associate Professor" in the Field of Higher Education - 5. Technical sciences, Professional Trend - 5.2. Electrical engineering, Electronics and Automation, scientific subject – "Industrial Electronics"*

Senior assist. prof. PhD Prodan Ivanov Prodanov is participating in the competition for Associate Professor, published in the Official Gazette, issue 68/31.07.2020 and on the website of TU-Gabrovo, for the needs of the Department of Electronics at the Faculty of Electrical Engineering and Electronics, Technical University of Gabrovo.

### 1. Brief background data

The candidate Senior Assist. Prof. Eng. Prodan Ivanov Prodanov is an engineer in Electronics and graduated from the Technical University of Gabrovo as a Bachelor of Electronics in 2004 and as a Master of Electronics in 2005 with excellent results. In the period 2006 – 2009 he was a full-time PhD student at the Department of Electronics at the Technical University of Gabrovo. In 2010 he defended his doctoral dissertation in front of the Higher Attestation Commission of Bulgaria on the topic of *Theoretical and experimental studies of power supplies for inductions heating technologies* in the scientific trend of **Industrial Electronics**. Since 2010 he has been an Assist. Prof. and Senior Assist. Prof. at the Department of Electronics. During his years of study, as an engineer and lecturer, he received a number of awards and certificates. As a lecturer at the Department of Electronics at the Technical University of Gabrovo, he is responsible for the methodological and material support of the practical training of students and for the scientific research activity. He speaks fluent English.

### 2. General overview of the submitted materials

The candidate is participating in the competition with:

- Textbooks – **1** (Reliability of Electronic Equipment)
- Manuals for laboratory exercises – **3** (Design and technologies of electronic equipment, Power supply devices and Electrical Drives)
- Publications – **38**.

Publications can be classified as follows:

**Publications, editions refereed and indexed by internationally acclaimed scientific databases, equivalent to habilitation work (a monography) - 11**

- Publications in international scientific conferences proceedings abroad – **2** [№ C4.2, C4.4];
- Publications in international scientific conferences proceedings in Bulgaria – **9** [№ C4.1, C4.3, C4.5 - C4.11].

**Publications, outside the group of publications equivalent to habilitation work (a monography): 27;**

- Publications in scientific journals and annuals in Bulgaria – **3** [№ D8.5, D8.10, D8.22];
- Publications in international scientific conference proceedings abroad – **1** [D7.1];
- Publications in international scientific conferences proceedings in Bulgaria – **23** [№ D7.2 - D7.4, D8.1 - D8.4, D8.6 - D8.9, D8.11 - D8.21, D8.23].

**By type:**

- Papers in international scientific conference proceedings - **3** [№ C4.2, C4.4, D7.1];
- Articles in national journals and annuals - **3** [№ D8.5, D8.10, D8.22];
- Papers in international scientific conferences proceedings in Bulgaria - **32** [№ C4.1, C4.3, C4.5 - C4.11, № D7.2 - D7.4, D8.1 - D8.4, D8.6 - D8.9, D8.11 - D8.21, D8.23].

**According to the language in which they are written:** 16 publications in English language; 22 publications in Bulgarian language.

**According to the numbers of co-authors:** independent publications – **6**; with one co-authors – **19**; with more than one co-author – **13**.

Of all the publications with which the candidate participates in the competition, a total of 22 publications are in Bulgarian (58%) and 16 publications are in English (42%). Of all the publications with which the candidate participates in the competition, he is an independent author or the first co-author of 26 publications, which is 68.42% of all submitted publications.

According to the minimum requirements for holding the academic position of Associate Professor in field 5 **Technical Sciences**, laid down in Art. 2b of the Act on Development of the Academic Staff in the Republic of Bulgaria, the points by different groups (required for the candidate, too) are presented in the following table:

<b>Group of indicators</b>	<b>Indicators</b>	<b>Min. number of points for Associate Professor</b>	<b>Number of points of the candidate</b>
A	Indicator 1	50	50
B	Indicator 2	-	-
C	Indicators 3 or 4	100	370
D	Sum of indicators from 5 to 11	200	318,36
E	Sum of indicators from 12 to 15	50	140

The above information is summarized as follows:

**Group of indicators A** (at least 50 points) – PhD thesis – **50 points**;

**Group of indicators B** - not required for the academic position Associate Professor;

**Group of Indicators C** (at least 100 points) - published a monographic work or equivalent scientific publications (not less than 10) in editions that have been refereed and indexed in world-renowned scientific information databases – the candidate has submitted **11** articles, equivalent to a monographic work, refereed in SCOPUS platform - **370 points**;

**Group of Indicators D** (at least 200 points) - scientific publications in non-refereed peer-reviewed journals or in edited collective volumes - **27** publications with different number of authors - **318.36 points**;

**Group of Indicators E** (at least 50 points) - citations in scientific publications, refereed and indexed in world-renowned databases – the candidate has submitted a list of **14** citations in refereed scientific publications of 5 of his scientific publications - **140 points**.

My general conclusion is that with the submitted publications, equivalent to a monographic work, other scientific publications outside this group, and the submitted list of citations, the candidate Senior Assist. Prof. Prodan Ivanov Prodanov fully meets the minimum national requirements for holding the academic position of Associate Professor for the field of **Technical Sciences** in higher education, laid down in Art. 2b of the Act on Development of the Academic Staff in the Republic of Bulgaria.

The minimum quantitative requirements for candidates for the academic position of Associate Professor, according to the rules of the Technical University - Gabrovo, are also met by the candidate Prodan Ivanov Prodanov, which can be seen from the following table:

<b>Indicators</b>	<b>Minimal requirements of the Technical University of Gabrovo for Associate Professor</b>	<b>Number of submitted materials by the candidate</b>
The total number of publications (articles and reports)	20 of which at least 4 independent and (1)* with IF (WoS)	38, of which 6 independent
Number of known citations from other authors	5	14
Number of textbooks and teaching guides	2	4
Project and contract management	1	1

\* The number in parentheses is recommendable.

### **3. Reflection of the Candidate's scientific publications in the scientific community (known citations)**

The Candidate, PhD Prodan Ivanov Prodanov, is participating in the competition with 14 citations. As a result of the submitted publication activity and the corresponding reflection by citations by other authors, the Candidate has a Hirsch index  $h = 3$  (according to SCOPUS database) and it can be concluded that he is known to the scientific community in the field of the competition.

### **4. Overview of the content and results of the submitted works**

The scientific works that Senior Assist. Prof. Prodan Ivanov Prodanov has submitted to participate in the competition for Associate Professor can be summarized in four main areas:

#### **- *Analisis of reliability of electronic elements***

This thematic group covers publications C4.3, C4.5, C4.7, C4.8, C4.10, D7.4, D8.5, D8.11, D8.22, D8.23 and chapters two, five and seven of the textbook for the course *Reliability of electronic systems*.

Publications C4.3, C4.5, C4.10, D8.5, D8.11 provide an overview of the main methodologies, proposing a new classification as a third branch has been added to it, to which the methodologies in mixed models can be assigned. - a combination of additive and multiplicative. Three methodologies have been analyzed, and conclusions have been drawn regarding the possibility of applying each of them with respect to power electronic elements - transistors, thyristors and diodes.

Publications C4.7, C4.10, D8.22 и D8.23 present the research and studies on the influence of the electrical and thermal modes on the reliability of power semiconductors. The useful knowledge from this research and studies is the ability to define the limit values of the thermal modes of a whole class of power semiconductors – power transistors, diodes and thyristors.

Publication D7.4 proposes a methodology for analyzing the reliability indicators of the power MOSFET transistors based on a model taking into account the thermal resistance of the cooling system. By implementing this model in the MIL-HDBK-217F methodology, it is possible to determine the maximum power losses of the transistors, as well as the maximum cooling water temperature when setting the boundary level of the reliability of transistors.

The possibility for expanding and adapting a specific methodology for failure rate analysis is presented in publication B4.8 when analyzing the reliability of supercapacitors. An analysis method based on models taking into account the aging processes in supercapacitors has been implemented.

#### **- *Analisis and modelling of reliability of electronic systems***

This thematic group covers publications C4.1, C4.2, C4.4, C4.6, C4.9, C4.11, D8.1, D8.3, D8.6, D8.9, D8.15 и D8.16 and chapters four and six of the textbook for the course *Reliability of electronic systems*.

A part of the publications C4.2, C4.9 and D8.3 are related to the analysis of the availability of an electronic system and evaluation of the effectiveness of the embedded protection circuits in a given electronic system. Probabilistic models are proposed defining the basic states of a given power supply for induction technologies. The obtained results have been used to evaluate the efficiency of the systems with duplication and redundancy, as well as the protection circuits by different electrical parameters in industrial energy converters.

Publications C4.11, C4.6 present a reliability analysis related to combining the three methods for reliability modelling – *Markov analysis*, *Fault Tree Method* and *Theory for preventive maintenance*. Six different probabilistic models have been proposed, which include the implementation of protection circuits in electronic devices, preventive maintenance and redundancy systems.

Publications C4.4 and D8.1 analyze the impact of the combinations of the environment parameters affecting the reliability indicators of the power supplies for induction heating technologies. A three-dimensional model has been proposed, which allows graphical determination of the reliability of the object compared to two of the operating parameters.

Publications C4.1, D8.6, D8.15 and D8.16 analyze the reliability of electronic systems, classified as a different class of devices. Measures for improving the reliability of the systems under study and defining the service life of the systems have been proposed.

**- Modeling and studying schemes and processes in converters of electric energy**

The publications in this thematic area are related to the modeling of the inductor-piece system in the processes of induction heating of cylindrical steel parts, as well as of flat parts in a magnetic circuit; modeling and simulation of power circuits of electric converters; construction of working prototypes and reconstruction of existing technical solutions.

Publications D7.1 and D7.2 propose an analysis of the electromagnetic processes of the inductor-piece system for heating steel cylindrical parts with differentiated domains of the magnetic field in it, as well as the inductor-piece system when heating in magnetic chain. For the analysis of the inductor-piece system upon heating in a magnetic circuit, an analysis model is applied, combining the adjustment method and harmonic analysis.

Publications D8.7, D8.16, D8.19. and D8.21 purpose and analyse simulation models of the following types of electronic converters: a two-transistor forward converter in an inverter welder; a driver circuit of a LED lamp; a capacitive energy conversion system, a switch mode power supply based on a specific integrated circuit Viper100. Schematic and technical solutions are proposed to improve the performance of the circuits modelled.

Publications D7.3, D8.2, D8.18 and D8.20 present a practical development of electronic schematic and functional blocks of power and control circuits in electronic converters of energy conversion systems. Control circuits for MOSFET transistors based on a specific driver circuit and resonant circuit have been developed, as well as low power circuits for induction heating of steel pieces. Prototypes of an induction cooker and a low-power induction pyrograph have been developed [D8.18, D8.20].

Reconstruction of separate functional units of the control system of a parallel current inverter for mass heating of steel parts has been performed [D8.2]. In publication D8.17 a technological assessment of an induction water heater system of HARVER CN30L type has been performed according to the requirements for safety, CE marking and energy consumption marking.

**- Modelling, construction and study of position electrical drives**

This thematic area covers publications D8.4, D8.8, D8.10, D8.13, D8.12 and a guide on *Electric Drive* for laboratory exercises.

Publications D8.4 and D8.12 consider stepper motors and the implementation of a simulation file with macros for studying and simulating the mechanical characteristics of stepper motors. The proposed mathematical model gives possibilities to: obtain electrical and mechanical characteristics of the stepper motor in the absence of catalog data; obtain a family of mechanical characteristics under different electrical modes.

Publications D8.8, D8.10 and D8.13. present studies related to the implementation and testing of a servo controller for controlling a DC servomotor. A modified model of a digital PID controller and a DC motor has been compiled to perform simulations in the MATLAB software product. A significant number of modifications have been made in terms of circuits and design, as a result of which a prototype of a servo controller for controlling a DC servomotor has been designed and constructed.

## **5. General characteristics of the Candidate's activities**

### **5.1. Teaching practice**

The Candidate for the academic position Associate Professor, PhD Prodan Ivanov Prodanov, has a total of 10-year teaching career at the Department of Electronics at the Technical University of Gabrovo. In the documents submitted for the competition a complete reference for the conducted classes has been attached. The Candidate has diverse and heavy teaching practice. He is a lead lecturer of the following academic courses: *Design and Development of electronic equipment*, *Design of communication equipment*, *Electrical Drives*, *Industrial electronic devices and systems - 2<sup>nd</sup> part*, *Reliability of electronic systems*. In addition, the Candidate delivers laboratory exercises for these courses to full- and part-time students following bachelor and master degree courses. The Candidate is responsible for the

methodological and material support of the practical training of students at the Department of Electronics. In the period 2010 – 2020, under the supervision of Senior Assist. PhD Prodan Ivanov Prodanov, a total 53 student have successfully defended their Bachelor's and Master's Degrees. The active work of the candidate with outstanding students makes a good impression - he was the scientific supervisor of 15 students who participated in the student scientific conferences organized by the Technical University of Gabrovo. Under the leadership of the Candidate on the territory of the Department of Electronics a laboratory of Schneider Electric Bulgaria Ltd. on Electric Driving Systems was established.

## **5.2. Scientific and applied-scientific activity**

The scientific works and developments of the Candidate are related to the following main areas:

### *A) Analysis of the reliability of the electronic elements: 10*

1.1. Analysis of the applicability, expansion and adaptiveness of different methodologies for calculations of the failure rates of electronic elements and supercapacitors – 5: C4.3, C4.5, C4.8, D8.5, D8.11.

1.2. Analysis of the influence of electrical and thermal parameters on the reliability of power semiconductors – 4: C4.7, C4.10, D8.22, D8.23.

1.3. Analysis of the reliability indicators of power MOSFET transistors, based on a model considering the thermal resistance of the cooling system – 1: D7.4.

### *B). Analysis and modeling of reliability of electronic systems: 12*

2.1. Analysis and modeling of probabilistic states, preventive maintenance time and availability of electronic systems – 5 C4.2, C4.6, C4.9, C4.11 and D8.3.

2.2 Analysis of the influence of the environment conditions on the reliability of electronic systems – 2: C4.4 and D8.1.

2.3. Analysis of the reliability of different types of electronic systems – 5: C4.1, D8.6, D8.9, D8.14 и D8.15.

### *C). Modeling and studying schematics and processes in converters of electric energy – 11*

3.1. Analysis of electromagnetic processes of an inductor-piece system for heating steel pieces – 2: D7.1 and D7.2

3.2. Analysis of power circuits in converters of electric energy – 4: D8.7, D8.16, D8.19 and D8.21.

3.3. Development of: devices for induction heating, control circuits for converters of electric energy, drivers for control of power semiconductors – 5: D7.3, D8.2, D8.17, D8.18 and D8.20.

### *D). Modelling, construction and study of position electrical drives – 5*

4.1. Modelling, construction and study of a servocontroller improving the dynamic characteristics of servo-driven systems for DC servomotors – 3: D8.8, D8.10 и D8.13.

4.2. Development of a mathematical model for obtaining the mechanical characteristics of stepper motors – 2: D8.4 and D8.12.

## **5.3. Implementation activities**

The Candidate, PhD Prodan Ivanov Prodanov, has submitted 4 official documents regarding the implementation of his scientific, scientific-applied and applied results of his research. The results of the reliability analysis of electronic converters for induction heating of steel parts, related to preventive maintenance and assessment of the impact of the operating environment conditions on the reliability, have been implemented on the territory of MADARA AD. Moreover, the Candidate has developed and implemented printed circuit boards and technical documentation of functional control units for a *starting device* and a *parallel current inverter*, located in a series of thyristor converters for induction heating of steel parts in the same enterprise. On the territory of IMG Union Ltd. and Ingeborg Demirova - Petar Karabadzhakov ET systems for controlling position electrical drives are designed, implemented and implemented have been designed and implemented in the following devices: a machine for winding of brushless dc motors (BLDC motors) and two 3D printers.

## **6. Contributions** (scientific, scientific-applied, applied)

The candidate's contributions are very well-balanced and arranged. I accept them as they are proposed.

### ***A – Scientific contributions***

- A new approach to analyzing the reliability indicators of power MOSFET transistors, based on a model considering the thermal resistance of the cooling system has been proposed.
- A method for analyzing supercapacitors on the basis of models considering the aging processes, which provides possibilities for defining the admissible temperature values, the operating voltage and the equivalent series resistance of the supercapacitors, has been proposed and implemented.
- A mathematical model has been developed and a 3D model for obtaining the area of reliable performance of electronic converters of energy as a function of the operating conditions has been proposed.
- A new approach to analyzing the electromagnetic processes of the inductor-piece system with differentiated domains of the magnetic field has been proposed.

### ***B – Scientific-applied contributions***

- A classification structure of the methods for analyzing the failure rates of electronic elements has been built and an analysis of the applicability of various methods has been made in relation to power semiconductor elements.
- A new approach to defining the limit values of the thermal modes of a whole class of power semiconductor elements – power transistors, diodes and thyristors has been presented.
- Probability models considering preventive maintenance time and functional reliability connections, including power ( $\geq 50$  kW) electronic converters of energy involving protection states, scheduled maintenance and repair, have been synthesized.
- Probability models of electric energy storage systems and energy converters considering protection states, redundancy, maintenance and scheduled repair, by means of which their availability function is modelled, have been synthesized.
- A model for analyzing electromagnetic processes of a quasi-resonant inverter combining the adjustment method and harmonic analysis has been synthesized.
- Simulation models have been proposed and simulation studies of the operating modes of a wide group of electronic circuits of electric energy converters have been done in P-SPICE environment, where parameters, which are hard to be experimentally measured, have been obtained.

### ***C – Applied contributions***

- The reliability of a wide group of electronic systems have been studied according to operating conditions and modes. In relation to the analysis done, the reliability characteristics and the service life have been identified and recommendations for improving reliability have been made.
- Probability models for defining the efficiency of the protection circuits in the power circuits of a series of thyristor converters for induction heating of steel pieces have been synthesized and simulated.
- A simulation equivalent model of a specific integrated circuit verified in P-SPICE environment and by means of real measurements has been proposed.
- Devices with improved functional possibilities, elements and ways of controlling have been developed, studied and implemented.
- A simulation model has been synthesized on the basis of a mathematical analysis of stepper motors so as to obtain a family of mechanical characteristics under different input parameters of the drive-stepper motor system.
- A modified model of a digital PID controller and a DC servomotor has been proposed and studied in MATLAB environment, on the basis of which a digital PID controller has been implemented.

## **7. Assessment of the Candidate's personal contribution**

One of the indicators of the Candidate's merits is his personal participation in the above contributions. In 6 of the 38 scientific articles and reports, PhD Prodan Prodanov is an independent author, in 19 he has one co-author and in the rest articles he has two or more co-authors. His comprehensive teaching and research activities prove for his high level of professional competence. The contents of the materials submitted for the competition clearly indicate that the Candidate is a highly-qualified professional and there is no doubt that the

scientific and applied contributions of the Candidate are individual work or team work involving his significant creative participation.

### **8. Critical notes and recommendations**

The following formal remarks can be made on the submitted documents:

- It would be good for the Candidate to publish in foreign journals with a high impact factor. The materials that he has provided for the competition suggest that he would be able to handle this task;
- Higher international activity and participation in European projects are desirable.

### **9. Personal impressions**

I know the candidate personally and I find his attitude to work, colleagues and students to be extremely professional. I believe that his scientific and research activities and the results achieved so far in the field of reliability of electronic elements and systems, modeling and research of electronic energy converters and position drives, demonstrate the creative potential of the Candidate very well. The candidate is fluent in English and as a lecturer has created a good scientific production for a young scientist.

### **10. Conclusion**

The Candidate, PhD. Prodan Prodanov, presents works and personal data which successfully defend his claims in the competition. The following summaries has influenced my conclusion regarding the competition:

1. The Candidate has submitted scientific papers that are sufficient in accordance with the established requirements for the scientific title of Associate Professor at national level and the minimum requirements of the Technical University - Gabrovo.
2. The Candidate demonstrates the qualities of a scientist in the field of design and reliability of electronic elements and systems.
3. He can set and solve scientific problems at the level of an established researcher - he masters the tools and is able to apply them.
4. He has original creative achievements at a high scientific level, sufficient in volume and significance for the award of the scientific title of Associate Professor.

**Taking in account the foregoing, I recommend to the esteemed scientific jury Senior Assist. Prof. PhD Prodan Ivanov Prodanov to be selected as an Associate Professor in the field of higher education - 5. Technical sciences, professional trend - 5.2. Electrical Engineering, Electronics and Automation, Scientific Subject – Industrial Electronics.**

03.12.2020

Reviewer: /signature/

/Prof. Raicho Todorov Ilarionov, D.Sc./