R E V I E W

in relation to awarding the academic position of Associate Professor
in professional field 5.2. Electrical Engineering, Electronics and Automatics,
scientific subject "Application of the principles and methods of cybernetics in various fields of science (biomedicine)"
promulgated in State Gazette, issue 69/16.08.2024 for the needs of the "Processing and Analysis of Biomedical Signals and Data" section at IBPhBME of BAS
Applicant: Tatyana Dimitrova Dobreva, PhD, Assistant Professor
Member of the Scientific Jury: Corresponding member of BAS Georgy Slavchev Mihov, DSc, Professor

1. Overall characterization and biography information

Tatyana Dimitrova Dobreva was born on August 30 1970, in the city of Sofia. She graduated from the Technical University of Sofia in 1995, Faculty of Communication Engineering and Technologies, majoring in "Radio and Television Technology" as a Master Engineer. In the years 2001-2003, he was a PhD student at the Central Laboratory of Biomedical Engineering at the Bulgarian Academy of Sciences (BAS). In 2003, she defended PhD thesis on "Quick sedation of electrocardiographic amplifier after defibrillation pulse". With protocol No. 6 of 14.04.2003, the Higher Attestation Commission (HAC) awarded the educational and scientific degree "Doctor of Philosophy" in the scientific specialty 02.21.07 "Automated systems for information processing and management in medicine".

In the years 1996-1999, she worked at the Institute of Special Electronics "Electron-Progress", Sofia as a design engineer, with the main activity and responsibility of designing microcontroller systems and programming microcontrollers. In 1999, she joined the Central Laboratory of Biomedical Engineering at BAS as a Constructor, in 2001 she was selected as a research associate III degree, and in 2010 she was selected as a research associate I degree. From 2011 to the present, she is the Assistant Professor at the Institute of Biophysics and Biomedical Engineering (IBPhBMI) of BAS.

2. General description of the presented materials

The applicant in the competition for the academic position "Associate Professor" PhD Tatyana Dobreva submitted all the necessary documents, according to the Regulations for the Implementation of the Law on the Development of the Academic Staff in the Republic of Bulgaria (RILDASRB) at IBPhBME of BAS and the requirements of the National Center for Information and Documentation (NCID). The documents include a total of 38 papers (10 equivalents to a monographic work), 10 citations and 2 patents.

The evidentiary material for fulfilling the minimum requirements for holding the academic position of "Associate Professor" in IBPhBMI of BAS corresponds to the following number of points:

The supporting material for fulfilling the minimum requirements for awarding the aca-demic position of "Associate Professor" at the Technical University of Sofia meets the following points:

Indicator A – 50 points (min. 50). It is presented a PhD No. 28538 of 26.06.2003, issued by the Higher Attestation Commission;

Indicator B[3)] – 189 points (min. 100). Ten papers equivalent to a monographic work are presented, which are referenced and indexed in world-renowned databases with scientific information (Web of Science, Scopus). All papers are co-authored, and in two of them PhD Dobreva is the first author [B4.4, B4.9]. One paper is in Q1 (Web of Science) [B4.3], six are in Q2 (Web of Science) [B4.1,2,5,7,8,9] and one is in Q3 (Web of Science) [B4.10].

Two papers are in Q3 (Scopus) [B4.4,6]. The papers under indicator B were cited a total of 176 times.

3) According to the specific requirements for the occupation of the academic position "Associate Professor" in IBPhBME of BAS, the candidate in the competition PhD Tatyana Dobreva has presented 8 papers with an IF impact factor (Web of Science) [B4.1,2,3,5,7,8,9,10];

Indicator Г – 311 items (min. 200) 28 scientific papers are presented, of which 10 according to indicator Г7 are referenced and indexed in world-renowned databases with scientific information (**163.33 points**). The remaining 18 papers under indicator Г8 are in non-refereed peer-reviewed journals or in edited collective works (**147.85 points**). All papers are co-authored, and in 6 of them PhD Dobreva is the first author [Г7.6; Г8.4,5,6,8,11]. Papers under indicator Г were cited a total of 47 times (Г7 – 20 times, Г8 – 27 times);

Indicator Д – 100 points (min. 50). According to indicator Д12, 10 citations of the article [B4.2] are presented. All citations are made in scientific issues, referenced and indexed in world-renowned databases of scientific information;

Indicator E – 80 points (not required for occupying the academic position "Associate Professor"). According to indicator E26, the participation of PhD Dobreva in two patents - BG67325 / 02.01.2018 "Method and device for correlated multiple sampling with high-order noise formation" and BG67598 / 17.12.2020 "Method and device for registering and synchronous filtering of biosignals".

3. General characteristics of the applicant's research and applied-science activities

The overall research and applied activity of the candidate in the competition, PhD. Dobreva, is in the domain of biomedical engineering, related to registration, processing and analysis of biomedical signals and data. The candidate's activities relate mainly to the development of circuit, program and combined solutions of measurement converters and amplifiers of biosignals and of filters for removing interference from ECG signals.

Dr. Dobreva took part in two national contracts with Ministries and other departments ("Design, manufacture and implementation of a device for transcranial direct current stimulation" - 20013-2014) Scientific research fund (2020-2024 – "Computer decision support for diagnosis of cardiac arrhythmias by machine learning and deep neural networks"), as well as in an international agreement with Schiller AG, Switzerland ("Methods and algorithms for registration, processing, analysis and classification of biomedical data, signals and images and their implementation through program and schematic solutions in electronic clinical and life-saving equipment" – from 2005, which continues to this day).

Applied contributions are visible in the candidate's papers, in the field of "High resolution recording and generation of ECG signals", the most important of which are:

In the articles equivalent to habilitation thesis – Developed 16-channel simulator of ECG signals, generating signals with a sampling rate of 2 kHz and a high resolution of 286 nV/bit by direct digital-to-analog conversion of data received through the USB port of computer [B4. 4].

Implemented programming procedure to transfer 12 standard leads to 8 independent, thus avoiding the need for a built-in Wilson common point circuit. Adapted specialized computer software in Visual-C for selecting and controlling the simulator's operating mode. The simulator complies with the international standard IEC 60601-2-47 / 2012.

In the articles for the competition of Associate Professor (outside the equivalents of habilitation thesis) – Developed 16-channel module for recording ECG signals with high resolution and sampling rate 2 kHz [Г8.5,6]. The module is suitable for recording high-

frequency waveforms at the microvolt level in the terminal part of the QRS complex in patients prone to sustained ventricular tachycardia. The module was utilized to collect an ECG database for the development and testing of methods for the applicability of ECG as a human biometric characteristic in different environments.

4. Major applied scientific contributions

The applicant PhD Dobreva has summarized the contributions related to the papers for participating in the competition for "Associate Professor" in four applied scientific fields.

4.1. *Contributions to articles equivalent to a habilitation thesis* – they can be defined as the <u>enrichment of existing schemes, devices and systems with new qualities and parameters</u>.

In the field "Measuring transducers for registering biosignals":

– developed circuit solutions of two-electrode amplifiers of biosignals without a reference electrode – in a differential version with a bootstrap positive feedback interface stage [B4.1], as well as a non-differential transimpedance amplifier with a virtual ground and parallel RC groups for equalization of input common-mode currents [B4.2], achieving high input impedance for the useful signal and low for common-mode disturbances;

– developed charge amplifiers with active negative feedback with low cutoff frequency of the bandpass [B4.3].

In the field "Adaptive filtering of electromyographic noise in ECG signals":

– designed adaptive low-pass filters – with pseudo-real-time dynamic change of the cut-off frequency [B4.5] and using a purpose-built "wings" function to estimate the frequency spectrum of the ECG waves [B4.6], preserving the signal morphology and improving the diagnostic capabilities of the ECG signal;

– created algorithm for the analysis of short single-channel ECG signals in the time domain and the classification of atrial fibrillation, normal sinus rhythm, other arrhythmias and strong noise, by means of the analysis of parameters reflecting the morphology of the ECG signal and cardiac variability [B4.7].

In the field "Filtering power-line interference from ECG signals (by synchronous filtering)":

– developed mixed analog-digital solutions of synchronous filters – with calculation of real and imaginary parts of the interference and subsequent subtraction from the useful signal [B4.10], by means of a software phase-locked loop for balancing the impedance bridge formed by the electrode impedances and the amplifier input impedances [B4.8];

– developed a digital synchronous filter based on software demodulation and subsequent remodulation of the power-line interference and subtracting its estimated value from the differential-mode input in real time [B4.9].

4.2. *Contributions in the articles for the competition of Associate Professor (outside the equivalents of habilitation thesis)*. To a large extent, they overlap with contributions in articles equivalent to habilitation work and can be characterized as <u>using existing knowledge for new applications</u>.

Contributions to the publications in the competition for associate professor (outside the equivalent of a habilitation thesis).

In the field "Measuring transducers for registering biosignals":

– developed schematic solutions of non-differential [Г8.1] and instrumental [Г8.2] amplifiers for low supply voltage, characterized by high differential and sufficiently low common-

mode input impedance, achieved by positive feedback;

– proposed concept for simultaneous recording of high-quality electrocardiogram (ECG) and bioimpedance (respiration) acquisition and schematic solution of an amplifier with current-driven inputs, providing low common-mode impedances of the current electrodes and high differential-mode impedance of the voltage electrodes. [Г8.3];

– developed measurement transducers for capturing biosignals from sensors with capacitive output impedances [Г7.1], having a low cut-off frequency of the band-pass;

– developed low-power photoplethysmograph for registering a peripheral pulse from the forehead area [Г8.4], allowing fast heart rate registration for use in emergency cases or in addition to defibrillators or monitoring systems.

– proposed and patented method and device for improving the Correlated Double Sampling technique to Correlated Multiple Sampling techniques [Г7.2, E26.1], having improved amplifier offset and flicker noise suppression.

In the field "Adaptive filtering of electromyographic noise in ECG signals":

– proposed original methods for separating EMG and ECG signals from a mixed signal, consisting of frequency estimation of the mixed signal, filtering the EMG signal and its subsequent subtraction from the mixed signal [Г7.3,4]. The techniques can be applied to suppress EMG noise in ECG signals as well as to suppress ECG noise in EMG signals;

– proposed locally-adaptive algorithms for myriad filtering, with adapting of linearity parameter depending on local signal estimates and with "hard" switching of the length settings of the sliding window [Г7.5].

In the field "Filtering power-line interference from ECG signals":

– developed comb filters with High-Q notches, based on first derivate or averaging – with a flat frequency response and notches at the harmonics of power-line interferences [Г8.7,9,12], for simultaneous suppression of base-line drift and power-line interference [Г8.10], to extract the odd harmonics of power-line interferences [Г8.8,11];

– proposed method for synthesizing fractional adaptive comb filters, adapting frequency responses to the frequency changes of the power-line interference [Г7.6];

– developed filters synchronized with the power-line frequency – without feedback in frequency domain [Г8.16], with continuous adaptive balance of the bridge formed by the electrode impedances and the amplifier's input common-mode impedances [Г8.15], with separate control of the active and reactive components of amplifier's input impedances [Г8.14,13], through software phase-locked bridge balancing circuit [Г7.7,8];

– designed software phase-locked circuit synchronized with the power-line frequency, generating a reference signal [Г8.17,18], intended for use in the processing of ECG signals;

– designed power-line synchronized software automatic gain control without feedback [Г7.9] and with feedback [Г7.10], designed to generate a constant amplitude power-line interference extracted from an in-phase signal during recording.

5. Significance of contributions for science and practice

The results obtained in the works of the applicant in the competition, PhD Tatyana Dobreva, are directly applicable in the scientific and applied field of Biomedical Engineering in the construction of devices and systems for registration, analysis and processing of biomedical signals.

The received certificates from Schiller AG – Switzerland prove the direct applicability of

4

developments with the participation of PhD Dobreva:

– method and software product "Adaptive low-pass filtering of electromyographic noise from electrocardiograms", implemented in series production of high-end ECG device CS-200 Excellence;

–'developed software tool for testing the reference value generator embedded in the Schiller spirometry library according to seven spirometry reference standards.

Outside of the citations in the competition for "Associate Professor", PhD Tatyana Dobreva presented a reference for all citations she noticed. In total, the citations are 258 in 36 articles with the author's participation. The papers for the competition were cited 223 times. 204 citations of 30 papers appear in Scopus. It can be claimed that the applicant in the competition is known among the scientific community in her field.

6. Critical notes and recommendations

I have no critical remarks about the applicant. The documentation for the competition is extremely precise and neatly prepared. There is verifiable evidentiary material regarding the activities and achievements of PhD Tatyana Dobreva. The quantitative indicators of the criteria for occupying the academic position "Associate Professor" at IBPhBMI of BAS have been exceeded.

I have certain remarks on the formulation of the applicant's contributions – they are highly fragmented and many of them lack the evaluation part (advantages for specific applications versus already existing solutions). Articles equivalent to a monographic thesis should be thematically united under one common research name, with separately stated contributions.

7. Personal impressions and opinion of the reviewer

I know PhD Tatyana Dobreva from her regular participation in the International Conference "Electronics - ET", where she gave meaningful reports. I do not participate in joint papers with the applicant and I am not a person related to her in the sense of § 1, item 5 of the Additional Regulations of the Law on the Development of the Academic Staff in the Republic of Bulgaria.

CONCLUSION

The presented materials comply with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application and the internal Regulations for the implementation of the Law in IBPhBMI of BAS. Based on the acquaintance with the presented scientific works, their importance, the contributions contained in them, I find it reasonable to propose Assistant Professor Tatyana Dimitrova Dobreva, PhD, to occupy the academic position of "Associate Professor" in the professional field 5.2. Electrical engineering, electronics and automation, scientific major "Application of the principles and methods of cybernetics in various fields of science (biomedicine)".

November 18, 2024

REVIEWER:

/Corr. Mem. of BAS Prof. DSc Eng. G. Mihov/