R E V I E W

by Prof. Mihail Matveev PhD, IBPhBMI - BAS, of the materials submitted for participation in a competition for the occupation of the academic position "Assoc. Prof." in the field of higher education 5. "Technical sciences", professional direction 5.2. "Electrical engineering, electronics and automation" (Application of the principles and methods of cybernetics in various fields of science (biomedicine).

In the competition announced for the needs of the "Processing and analysis of biomedical signals and data" section at the IBPhBMI, published in the Official Gazette, no. 69/16.082024, based on Art. 5.9. from the Regulations for the application of LDASRB in IBFBMI, as the only candidate participates Chief Assistant Professor Tatyana Dimitrova Dobreva, PhD, from the same section.

1. Brief biographical data about the candidate

The candidate, Dr. Tatyana Dobreva, has completed higher education, a master's degree in Technical University - Sofia, Faculty of Communication Techniques and Technologies, major in "Radio and Television Technology" in 1995. From 1996 to 1999 he worked as design engineer at the Electron-Progress Institute for Special Electronics in the district of design and programming of microcontroller systems. Since 1999, he has been working at the BAS, initially at the Central Laboratory of Biomedical Engineering, subsequently at Institute of Biophysics and Biomedical Engineering, holding consecutively positions specialist, research assistant III-II-I degree, chief assistant. From 2001 to 2003 is a PhD student at the Central Laboratory of Biomedical Engineering and defends dissertation for PhD in scientific specialty 02.21.07 "Automated systems for information processing and management (in medicine)' on the topic 'Rapid pacification of electrocardiographic amplifier after a defibrillation pulse'.

2. General description of the presented materials

According to Appendix 2 of the Regulations for the Implementation of the Law on the Development of the Academic Staff in the Republic of Bulgaria at the Institute of Biophysics and Biomedical Engineering at the BAS, which defines the minimum requirements for occupying the academic post "Assoc. Prof." in area 5. "Technical Sciences", determine the following ratio between the minimum requirements and the evaluations of the submitted materials by the candidate:

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A group of indicators	Indicator	Minimum required points for associate professor	Candidate Points
A	1. Dissertation for award of educational and scientific degree "PhD"	50	50
B	2. Dissertation work for the award of scientific Doctor of Science degree	x	x
C	4. Habilitation work - scientific publications in publications that are referenced and indexed in world-renowned databases of scientific information	100	189
D	7. Scientific publication in publications that are referenced and indexed in world famous databases of scientific information 8. Scientific publication in non-refereed peer-reviewed journals or in edited collective volumes	200	311
E	12. Citations or reviews in scientific publications, referenced and indexed in world-renowned databases of scientific information or in monographs and collective volumes	50	100
F	26. Recognized utility model, patent or copyright application	0	80

It can be seen that the candidate exceeds the requirements for occupying the academic position announced in the competition.

3. Reflection of scientific materials in the scientific community

Outside of the open citations of scientific publications – a total of over 250, 8 publications with a total impact factor of 19.737 (of which 1 has IF=4.325) and 6 articles with SGR are presented in the professional scientific space. It is evident from these data that in the applicant's professional field of research, the results of her research are well known. The 17 participations of the candidate in the International Scientific Conference "Electronic Technology" testify to the information of the national and international scientific collegium.

4. Overview of the content and results in the presented works

In summary, the candidate's research concerns:
- registration and filtering (removal of low-frequency, high-frequency and power line interference) of various biosignals - mainly the bioelectrical heart signal and its electrocardiographic (ECG) recordings;

- recording of heart rate by means of photoplethysmographic signals;
- recording of the respiratory function through impedance plethysmographic signals;
- processing and analysis of electromyographic (EMG) signals.

5. General characteristics of the applicant's activity

The candidate's publications cover developments for recording various biosignals (ECG, pulse, respiration) through various measuring transducers such as amplifiers without a reference electrode, sources with capacitive output impedances, phototransducers. The more important contributions in this section, presented in the publications for participation in this competition, I formulate in general as follows:
- measuring transducers for registering biosignals;
- high-bit (24 bit) recording and generation of ECG signals;
- adaptive filtering of electromyographic noise in ECG signals;
- filtering power line interference from ECG signals.

6. Basic contributions with a significant scientific component and scientific-applied contributions

Based on the general characteristic of the applicant's activity, in more detail
I systematize the contributions as follows:

Measurement transducers for recording biosignals.
1. Innovative circuit solutions of differential and non-differential amplifiers of biosignals without reference electrode have been developed. A significant contribution to the circuitry of two-electrode biosignal amplifiers is the high input impedance achieved for the useful signal and low for common-mode interference. The proposed solutions are applicable for two-electrode recording of ECG signals in two-electrode applications such as defibrillators, ambulatory monitors and others.

2. A schematic solution has been developed for simultaneous recording of a high-quality electrocardiogram (ECG) and bioimpedance (breathing). This is achieved thanks to a specially designed amplifier with current-controlled inputs, providing low common-mode impedances on the current electrodes and high differential impedance on the voltage electrodes. The main advantage of the concept is that mains-frequency interfering currents flow through the current electrodes and not through the voltage electrodes, and thus a p interference-free ECG signal is obtained.

3. Innovative measuring transducers have been developed for capturing biosignals from sensors with capacitive output impedances, such as signals from capacitive electrodes or from piezoelectric sensors. A significant contribution is the automatic determination of the operating point through active negative feedback, which achieves a low cut-off frequency of the passband (0.05 Hz), allowing the recording of ECG signals for diagnostic purposes.

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4. A phototransducer was developed for registering a peripheral pulse from the forehead area. The device is designed to generate an additional signal corresponding to cardiac activity for use with portable automated external defibrillators.

5. A method and device have been implemented and patented in which correlated double sampling (a widely used technique in sensor signal processing) is advanced to correlated multiple sampling techniques. At the cost of processing more discretes, the new CMS techniques greatly improve the offset and low-frequency noise suppression of the measurement transducer.

High-bit (24 bit) recording and generation of ECG signals.

6.The high-resolution analog-to-digital data conversion implemented makes the system suitable for recording late potentials, which are high-frequency microvolt-level waveforms at the end of the QRS complex in patients prone to sustained ventricular tachycardia. The method has been applied to collect an ECG database in order to develop and test methods for face recognition through ECG. Such a database could support the definition of the optimal number of ECG leads and the optimal set of features, and would facilitate the decision on the applicability of the ECG as a human biometric feature in different environments.

7. An ECG signal simulator has been developed, which is an ECG device tester that generates high-resolution signals by direct digital-to-analog conversion of data from a computer. The modern design of electrocardiographic simulators must comply with the international standard IEC 60601-2-47, issued in 2012, which recommends that ECG measurements, detections and interpretive reports be tested using digitized ECG signals taken from five standard databases .

Adaptive filtering of electromyographic noise in ECG signals.
8. An adaptive low-pass filter has been designed, self-tuning to the frequency spectrum of the ECG waves. The filter is based on the Savitzky-Golay approximation procedure with a dynamic change of the cut-off frequency. The latest American Heart Association filtering recommendations are met. The characteristics of the filter allow it to be used as part of the pre-processing of a single-channel ECG for the classification of atrial fibrillation, normal sinus rhythm, other arrhythmias and loud noise, by means of the analysis of parameters reflecting the morphology of the ECG signal and cardiac variability.

9. Locally-adaptive algorithms for filters based on the basis of median filters are proposed, which extract the median value of the signal from the processed window with a linearity parameter K, depending on the local estimates of the signal and with "hard" switching of the length settings of the sliding window and a coefficient that affects the K parameter.

Filtering power line interference from ECG signals
10. Various comb filters based on first difference or averaging have been developed. In order to preserve the efficiency of the comb filters when the network frequency differs from its nominal value and to have their crests coincide with the harmonics of the changed network frequency, a simple method for synthesizing fractionally adaptive filters is proposed, in which the frequency

response is shifted in an arbitrary fractional step and adapts to the new power line frequency value.

11. A filter was developed using a mixed analog-digital solution for automatic balancing of the impedance bridge formed by the electrode impedances and the input impedances of the amplifier. Power line interference is removed by adding a portion of the common-mode voltage, with automatically adjusted amplitude and phase, to the useful differential biosignal. The described method provides high-quality biosignals without the need for an in-phase reference electrode.

12. A digital filter with synchronous filtering was developed. It is based on digital demodulation and subsequent remodulation, through synchronous processing of the differential and common-phase signals. The demodulator and remodulator are closed in a negative feedback loop that automatically subtracts real-time calculated power line interference from the input differential signal.

13. A software phase-locked loop (PLL) generating a reference signal synchronous with the in-phase power line is designed. The phase-locked loop is derived from its analog prototype by using a backward difference for s-domain to z-domain correspondence.

14. Software automatic gain adjustment without feedback and with feedback are designed. They are designed to generate a constant amplitude power line extracted from the in-phase signal during recording of ECG biopotentials.

7. Significance of contributions and implementation of research results

The candidate's activity in the professional field of research has impressive evidence of scientific, scientific-applied contribution and innovation effect. In the previous section I outlined the scientific and applied scientific contributions, but the practical and implementation results of the candidate's research.
Ch. Associate Professor Tatiana Dobreva, Ph.D., is a co-author of two patents:
BG67598. Method and device for recording and synchronous filtering of biosignals
BG67325. Method and device for correlated multiple sampling with high-order noise shaping.
She is the co-author of a certificate issued by a leading European company in the field of medical equipment, Schiller AG, Switzerland, for the implementation of the designed adaptive low-pass filter for filtering electromyographic noise from electrocardiograms in a high-end ECG device CS-200 Excellence. This ECG device has been implemented in serial production.

8. Evaluation of the candidate's personal contribution

Out of the total number of 40 scientific papers submitted for participation in the competition for the academic position "Assoc.Prof.", in 8 ch. Assistant Professor T. Dobreva is the first author. Here it should be reminded that the field of biomedical engineering in which she works is multidisciplinary and practically requires work in a collective, which limits the publication of a

I know Chief Assistant. Dr. Tatiana Dobreva from the moment she joined the Central Laboratory of Biomedical Engineering and the legal successor after 2010 – the Institute of Biophysics and
Biomedical Engineering, where she is part of the Biomedical Signal and Data Processing and Analysis Section. In the Section she distinguished herself by her precise work as specialist, authoritative colleague, with skills to work in a team.

11. Conclusion

From the presented materials for scientific, applied science and implementation activity on the competition for the occupation of the academic position "Docent" in the field of higher education 5. "Technical sciences", professional direction 5.2. "Electrical engineering, electronics and automation" (Application of the principles and methods of cybernetics in various fields of science (biomedicine) for the needs of the section "Processing and analysis of biomedical data and signals" in IBFBMI, it can be seen that the **Chief Assistant Tatyana Dimitrova, PhD has significant contributions and achievements, which are known to the professional college in our country and abroad "Assoc.Prof." for the needs of IBPhBMI - BAS.**
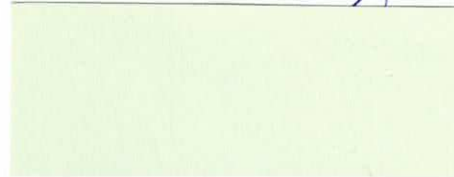
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