Development of Hardware-Software Test Bench For Optical Non-Invasive Glucometer Improvement

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***Abstract*—Hardware-software test bench for experimental approbation of methods for improving accuracy of BG measurement by optical non-invasive glucometer was developed. The test bench comprises hard PVC rail, sliding carriages with holders for flow-through cuvettes, light source and photodiode. Test solution with glucose and other blood substances are circulated between constant-temperature reservoir with stirring and the cuvette. To control glucometer optical system computer interface was developed. Software user interface allows setting measurement modes and provides real-time visualization of measured values.**

***Keywords*—test bench, glucometer, optical method, non-invasive.**

I. Introduction

Diabetes mellitus is the third widespread lethal disease in the world. It is an endocrine disease, characterized by chronic increase of blood glucose concentration (BG) that occurs when pancreas is no longer available to produce enough amount of insulin. Patients suffering from diabetes mellitus need continuous control of BG.

Up-to-date non-invasive glucometer embodiments have low accuracy that does not comply with requirements of international standard ISO 15197-2013 [1].

An embodiment of portable optical non-invasive glucometer was developed. Optical methods are sensitive to different factors like laser and photodiode temperature, object thickness and temperature etc. To evaluate these factors effect on BG measurement accuracy and to carry out experimental approbation of methods for improving accuracy special test bench is needed.

II. Specification

Test bench must allow modeling of a biotechnical system of BG measurement. BG measurement is to be carried out with blood test solutions. Such solutions can contain glucose and water, as well as other blood components, including scattering centers.

To evaluate object temperature effect on measurements it is required to keep blood test solution temperature constant. It is also required to provide solution circulation through the cuvette. To make cuvette leak-proof it was suggested to use flow-through cuvettes with Luer-lock (Female) connectors. Optical system is positioned on the same optical axis by portable optical rail.

To carry out the research of methods for accuracy improvement computer interface is required. Software must provide glucometer optical system control, real-time visualization of measured values and its further saving.

III. Development

As a result it was developed a hardware-software test bench for accuracy of BG measurement by optical non-invasive glucometer improvement methods approbation (figure 1).

Test bench comprises:

- Hard PVC rail with fixing holes
- Sliding carriages with cuvette holders
- Optical glucometer
- Sliding carriages with holders for light source and photodiode
- Interface cables
- Quartz flow-through cuvettes
- Tubing set
- Diaphragm pump
- Pump control unit
- Constant-temperature reservoir with test solution
- Magnetic stirrer
- PC

Test bench operates the following way. In the constant-temperature reservoir the blood test solution is placed. Solution can comprise water or peritoneal dialysis solution containing non-organic blood components. Solution is continuously stirring by magnetic stirrer. To the base solution the required amount of glucose is added. For better efficiency evaluation of methods for accuracy improvement high glucose concentrations are used.

The constant-temperature reservoir is connected (by tubes) to leak-proof quartz flow-through cuvette with mounted needles with Luer-lock connectors. Fluid circulation is provided by diaphragm pump on speed 5 ml/min. The pump is

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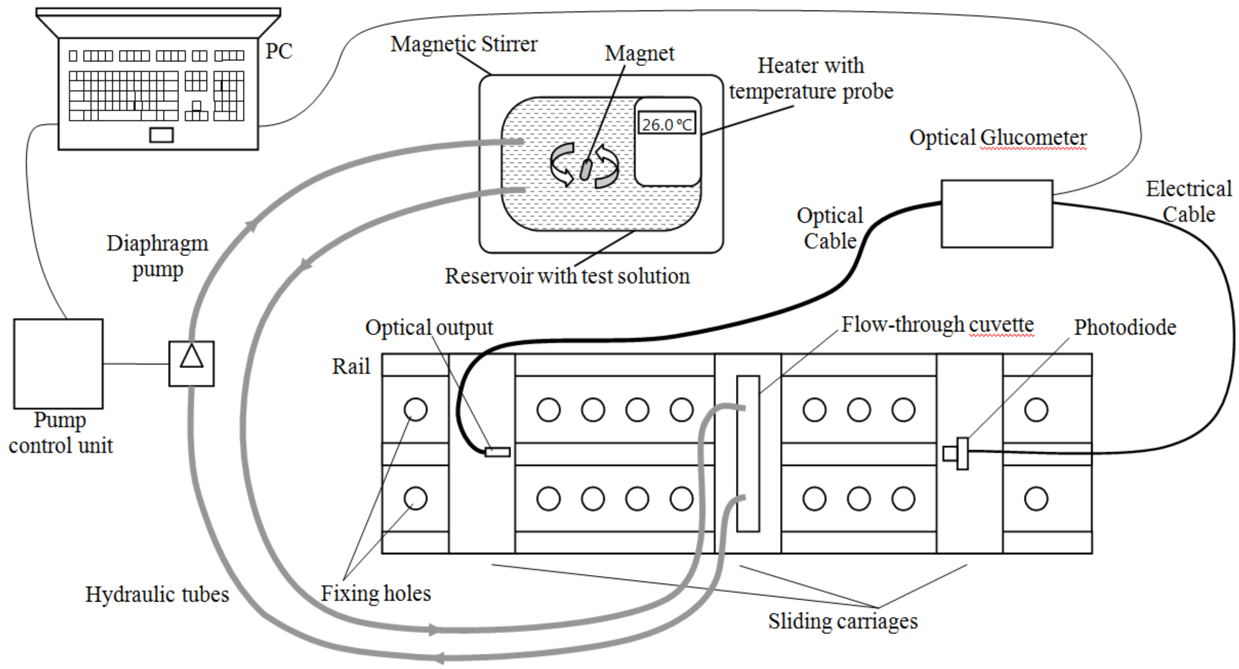

Fig.1. Test bench scheme

controlled by pump control unit. Cuvettes, light source and photodiode are installed into sliding carriages. The sliding carriages are installed on the hard PVC rail and are fixed by screw bolts. By using the rail and sliding carriages light source, photodiode and cuvettes are placed on the same optical axis.

Besides hardware for the test bench user interface was developed in the software design environment Qt to control glucometer optical system. The main window of the interface is presented in figure 2.

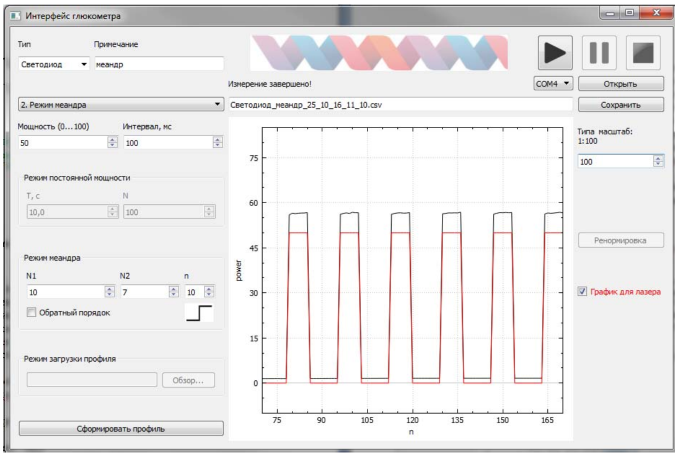

Fig.2. User interface main window

User interface allows:

- Creating or loading a measuring profile, that contains laser power data
- Optical glucometer measurement control
- Measurement parameters setting such as measurement mode (constant, square waveform or profile loading operation modes), laser power (0 – 100%), measurement delay (10 – 10000 ms), measurement amount
- Photodiode data real-time visualization
- Selective laser power graph visualization
- Graphs scaling and renorming
- Measurement results saving for its further processing

IV. Conclusions

Hardware-software test bench for efficiency evaluation of methods for improving non-invasive optical BG measurement accuracy was developed. Developed bench provides fixed temperature solution circulation through the cuvette that makes possible to continuously change chemical constitution of a blood model solution. Moreover test bench allows evaluation of distance between light source and photodiode and object thickness affect on BG measurement accuracy.

Software user interface controls glucometer optical system allows setting measurement modes and provides real-time visualization of measured values.

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References

[1] ISO 15197:2013. In vitro diagnostic test systems - Requirements for blood glucose monitoring systems for self-testing in managing diabetes mellitus / International Organization for Standardization, 2013.