TESTER OF BLOOD PRESSURE METERS

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ABSTRACT

The main objective of this paper is to design and implement an automatic manometre testing system with logging function. The paper describes the basic principles of non-invasive measurement of blood pressure, mainly used by such devices. On the basis of analysis of the automatic blood pressure measurement devices (ABPMD), we developed a solution consisting of a personal computer and a control module and both the hardware and software for the system have been designed as well.

1. INTRODUCTION

There has been a big expansion of personal blood pressure meters in recent years. These devices are certificated in accordance with the standardized protocols developed by the British Hypertension Society, the Association for the Advancement of Medical Instrumentation and others [2]. It is known that the devices should measure incorrect values for a large number of individuals although it met the criteria of the protocols. We developed a system which allows additional revision of such devices. This system is also able to execute separate measurement.

The hardware part consists of a micro-controller 68HC908GP32 (Freescale), to which a 16-bit A/D converter AD7715-5 (Analog Devices) is added, and its support circuits.

The software part consists of a micro-controller program written in the language of symbolic instruction code, and a computer program written in Borland C++ Builder developing environment. The software enables both automatic and manual evaluation of measured values and can store them in XML based databases.

2. METHODS

There are several methods for noninvasive discontinuous blood pressure measurements. Most common are oscillometric, auscultatory or their combination. Automatic blood pressure devices mainly use the oscillometric method[7].

2.1. OSCILLOMETRY MEASUREMENT

The cuff placed around left limb is inflated from above the systolic pressure. Then, the limb and its vasculature are compressed by the inflatable compression cuff. The blood pressure reading for systolic and diastolic blood pressure values are read at the parameter identification point. The simplified measurement principle of the oscillometric method is a measurement of the amplitude of pressure change in the cuff as the cuff is inflated from above the systolic pressure. The amplitude suddenly grows larger as the pulse breaks through the occlusion. This is very close to systolic pressure. As the cuff pressure is further reduced, the pulsation increase in amplitude, reaches a maximum and then diminishes rapidly. The index of diastolic pressure is taken where this rapid transition begins. Therefore, the systolic blood pressure (SP) and diastolic blood pressure (DP) are obtained by identifying the region where there is a rapid increase and then a decrease in the amplitude of the pulses respectively. Mean arterial pressure (MP) is located at the point of maximum oscillation [8].

The principle is illustrated by Fig. 1 and Fig. 2. Fig. 1 shows the signal on the output of the pressure sensor. Fig 2 shows extracted oscillation.

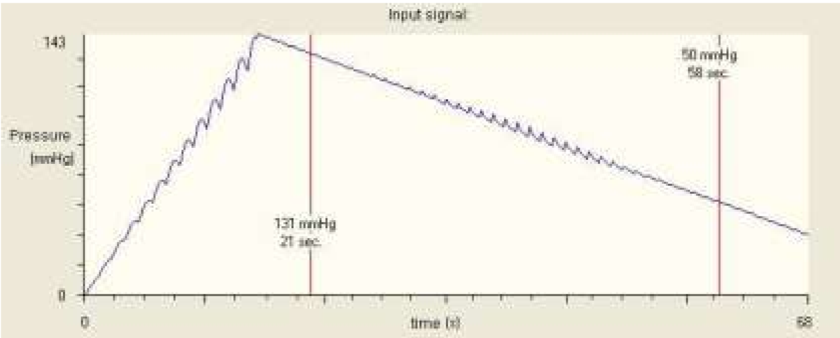

Figure 1: Signal at the output of sensor.

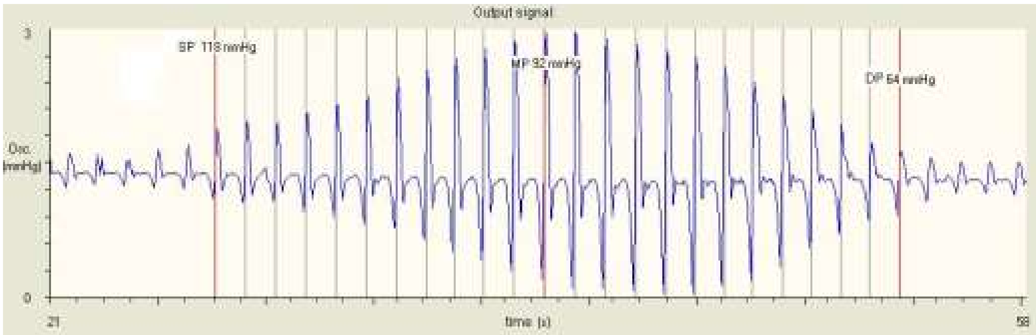

Figure 2: Oscillation signal.

2.2. MEASUREMENT DIFFICUILTIES

There are no difficulties with accuracy of pressure measurement. The problem is in correct interpretation of measurement data. The quality of the oscillation curve is usually worse than the Fig. 2 shows. The noise, motion artefact, gain shift etc. are often present and therefore the evaluation is complicated. There is also problem with patients having no ordinal curve shapes.

2.3. TESTING OF DEVICES AND BLOOD PRESSURE MEASUREMENT

We have developed a system for blood pressure measurement and for testing automatic blood pressure measurement devices. The principle is based on a simple idea. We measure the pressure in the cuff during the process of measurement and then we make its separate evaluation. We also make automatic evaluation like ABPD does, but we also can check result at a glance which is the main advantage of the developed system. The measured data are also saved in database and it is obvious that it can be evaluated anytime again.

3. DESIGNED SYSTEM

The designed system consists of two parts: 1. tester module, and 2. personal computer with installed software. Fig. 3 shows the system block diagram. The tester modul is used to measure pressure in the cuff and transmits relevant data to the PC. The measured data are processed and evaluated by the developed software.

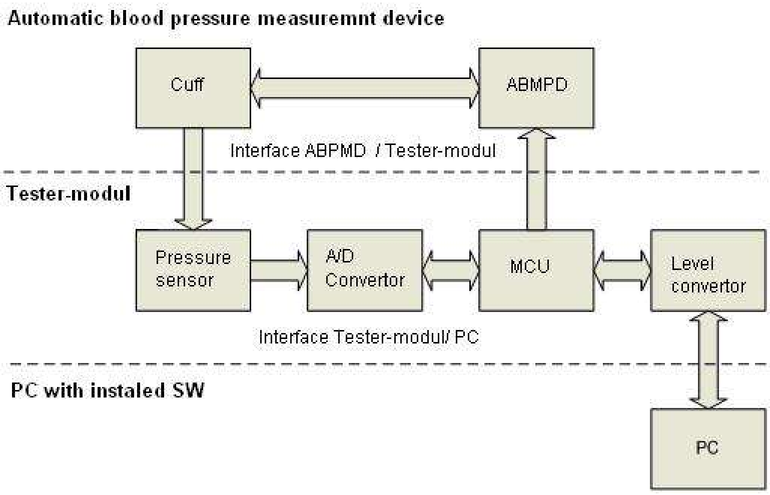

Figure 3: System block diagram.

3.1. DEVELOPED SOFTWARE

Fig. 4 shows the software block diagram. The software enables both automatic and manual evaluation of the measured values and can store them in XML based databases. The filtration is based on application of a non-recursive high-pass filter (N=200, f_H=1.38 Hz). The filtration is performed by convolution of the input signal and the impulse response of the designed filter (1) [1].

$$y(n) = \sum_{i=0}^{N-1} h(i)x(n-i) \quad (1)$$

The automatic evaluation consists of two main phases. First it is an automatic measure out of the oscillation signal. Second it is its evaluation. Evaluation should be done manually if needed.

The automatic measure out is done by an algorithm based on the principle of hysteresis and zone of insensitiveness.

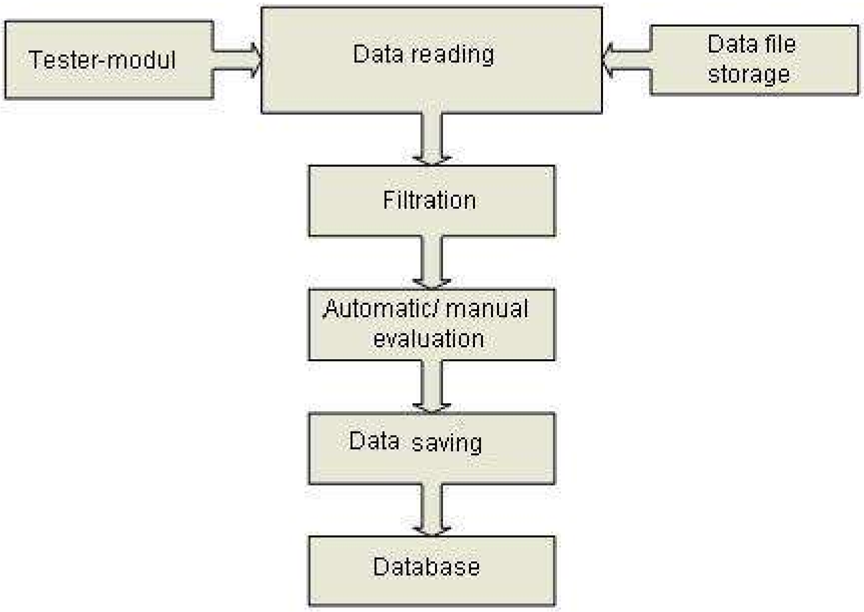

Figure 4: Software block diagram.

The system includes two algorithms for automatic evaluation. The first is based on the method of the biggest fall (high derivation) and the second is based on well known expression (2).

$$SP = 3\ MP - 2\ DP \tag{2}$$

4. RESULTS

The developed system is able to test automatic blood pressure measurement devices using the simple oscillometry method as well as devices using Fuze Pulse Qualifier[3]. We found out that the system is very useful in case of measurement in patients with abnormal oscillation curve. Common systems are able to resolve the curve as shown in Fig. 5 but always fail with the curve as we can see on Fig. 6. Neither the conventional Korotkoff method is able to measure patients with abnormalities shown in Fig. 6 but the system is. It is obvious that in this case the manual evaluation is needed.

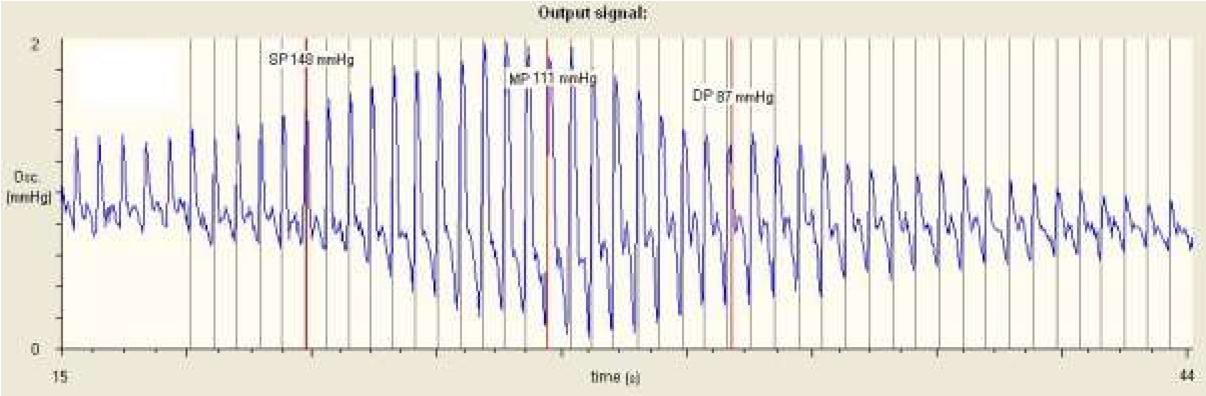

Figure 5: Normal oscillation signal.

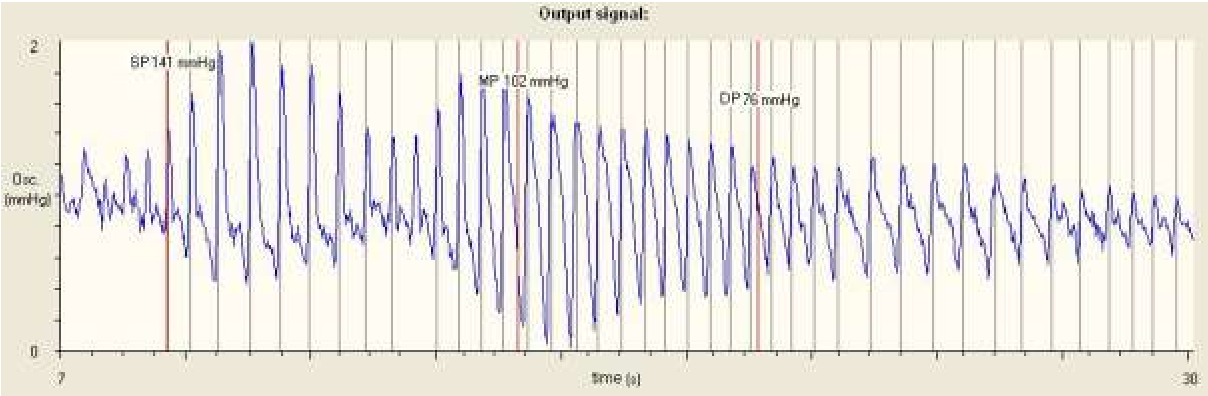

Figure 6: Abnormal oscillation signal.

ACKNOWLEDGEMENT

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REFERENCES

[1] JAN, J.; KOZUMPLÍK, J.; KOLÁŘ, R., et al. *Číslicové zpracování a analýza signálů*. Počítačové cvičení. Brno: VUT Brno, 2003.

[2] O'BRIEN, E.; PICKERING, T.; ASMAR, R. et al. Blood Press Monit. Working Group on Blood Pressure Monitoring of the EuropeanSociety of Hypertension International Protocol for Validation of Blood PressureMeasuring Devices in Adults, 2002.

[3] COLAK, S.; ISIK, S. *Fuze Pulse Qualifier.* Department of Electrical Engineering & Computer Science College of Engineering and Computer Science Syracuse University, 2004.

[4] Medscape. *Comparison of Oscillometric and Auscultatory Blood Pressure Measurement Methods* [online].
Dostupné z WWW http://www.medscape.com/viewarticle/514540_Tables#T1

[5] *Digital Blood Pressure Meter.* AN1571/D,1997. Motorola; Freescale Semiconductor, Inc. Dostupné z WWW http://www.freescale.com