Experimental Equipment for Data Collection

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***Abstract* — This article discusses a prototype device that enables a collection of variety signals. This device can be used in many areas of human activity such as audio signal processing, health care services or electrical industry. The signals can be recorded using non-invasive sensors mounted on the signal source. The aim of the device being described is to sample and record specific signal in order to its subsequent processing and utilization. The application of this device for the ECG and PPG signals measuring is suggested here.**

***Keywords* — signals, measuring, processing.**

I. Introduction

Problems of blood pressure measurement have been monitored very intensively since the blood pressure was measured for the first time. This is quite understandable, because data on blood pressure give important information on the status of the circulatory system.

One of the possible methods for measuring blood pressure is to monitor the changes in the delay of throb waves in relation to changes in blood pressure [3]. In this case, it is possible to consider two variants of measurement.

1. used as a reference point is the top of the electrocardiogram R-wave, and the period between the electrocardiogram R-wave and the peak of the photoplethysmograph (PPG) curve is measured. The photoplethysmograph curve is measured at another point of the artery.

2. the apex of the throb wave sensed in the artery closer to the heart is used as the reference point, and the period is measured between the reference wave and the wave throb detected on the artery located farther from the heart (using a pair of photoplethysmograph sensors).

Using the apex of the electrocardiogram R-wave as the reference point for the next measurement is advantageous, because blood pressure monitoring function can complement the electrocardiogram (ECG) holter. So far it has not been sufficiently demonstrated that the R-wave as a marker is a stable or unstable marker. Views differ on this issue. Locating single-use electrodes, for example, on the chest is easier than long-term attachment of reflective photoplethysmograph sensors on limbs.

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II. Monitor for Recording Experimental Data

Experimental equipment for data collection is referred to as “MULTIHOLTER”. Non-invasive blood pressure measurement is absolutely safe because the device is powered by low voltage battery [1]. Data to be used for subsequent analysis of the signal received in relation to blood pressure will be obtained on volunteers. Since this is an experimental device, it should allow for easy replacement from the viewpoint of signal sensing and our intentions to find a connection between changes in signal parameters and blood pressure.

In this experiment, it is possible to use 2 combinations of measurement methods.

1. ECG + photoplethysmograph sensor

2. photoplethysmograph sensor + photoplethysmograph sensor

From the Figure 1 it is apparent that the entire electronic device is divided into two sub-units. One of them is the analog part and the other the digital part.

Given that the signals can easily be scanned to adjust their levels prior to digitization, it is clear that variability will affect only the analog part, while the digital part will be the same for both cases. Estimated maximum period for scanning is 48 hours. The frequency of measurement in this interval is at least four measurements during one hour. The time for one measurement capture is at least 20 pulses.

During the time when the device is in a state of waiting for the moment of measurement, power consumption of all parts of the device is low, because all integrated circuits are in the power save mode. Increased power consumption occurs at the time of measurement. This is due to two factors. The first factor is the high power consumption of IR LED, which is used in the photoplethysmograph sensor. The second factor affecting the power consumption is the SD card write operation, which is used to save the data acquired. The capacity of the SD Card used is 2 gigabytes.

Subsequent analysis of the signal measured will be carried out in a workstation using a specially created application.

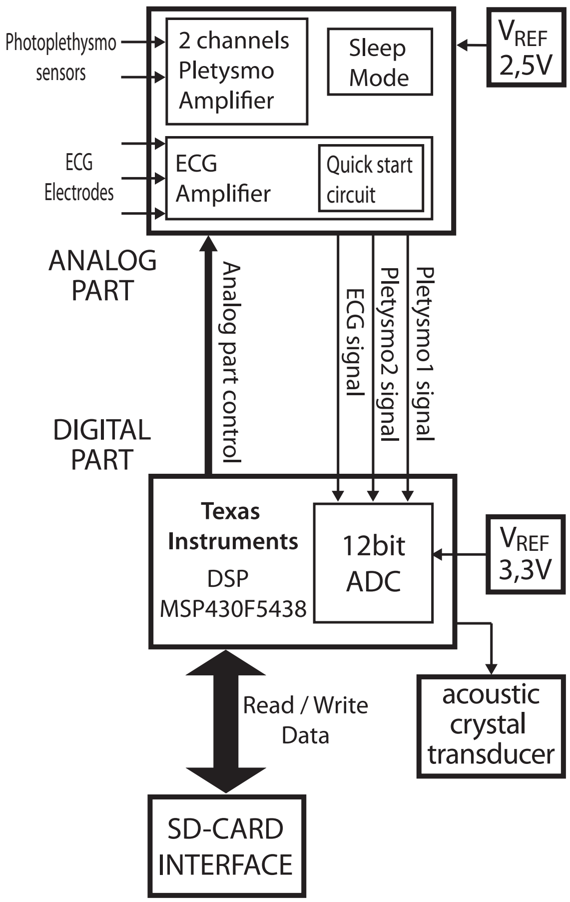

Figure 1: Multiholter device architecture.

A. Description of MULTIHOLTER´S electronic components

As described above, MULTIHOLTER consists of digital and analog parts.

B. Digital part

The basic part of the digital part is the digital signal processor Texas Instruments MSP430F5438. The processor was chosen because of its good features and integrated peripherals (timers, A/D converters, enough SRAM). The processor performs all calculations associated with the scanning of analog values and converts them to digital form, monitoring moments for measurement, SD card read/write operation, and power management.

The signals measured are sampled by a 12-bit analog-to-digital converter, whose resolution is sufficient for this activity. The fact that the 12-bit analog-to-digital converter is an embedded part of processor, makes their management and configuration easier via the program code of processor.

The amplified ECG signal at the output of ECG amplifier, as well as the signal from the photoplethysmograph sensor are each separately connected to one input of the analog-to-digital converter, where they are sampled with a frequency of 2 kHz. The sampling frequency is large enough to capture even relatively small temporal changes in the waveforms detected.

The device is equipped with a removable sensing SD (Secure Digital) card, which is used for data storage. Saving the acquired data by this type of storage media is appropriate not only because of its large capacity, but also because of the subsequent processing of stored data, which is performed in the service application on a PC. To make working with the data easier, the FAT32 file system support was implemented in the processor. For each volunteer their own file can be created, in which their measured ECG signals and photoplethysmograph signals or 2 photoplethysmograph signals are written.

The last element of the digital part is the acoustic crystal transducer. It is activated sufficiently long before the beginning of measurement. A sound signal informs the patient of the coming beginning of measurement, which should make the patient behave in accordance with the instructions received, to ensure a successful measurement.

C. Analog part

The analog part consists of three low-frequency amplifiers. Two are used to amplify the photoplethysmograph signal from the photodiode of sensors, and one is used to measure the ECG signal. Given that for each new turn on the ECG in the pre-event temporary plot this takes a relatively long time with regard to the lower marginal rate, which the amplifier transmits, the amplifier also contains the quick-start circuit whose task is to shorten the period of transition to a minimum. The quick-start circuit is commonly used in all electrocardiographs. At the beginning of measurement the control of analog part consists of the following procedures:

1. Running the acoustic signal. Warning of the beginning of measurement
2. Awakening the circuits from the power save mode
3. Switching on the quick-start circuit, which shortens the time constant of ECG amplifier to a very short time. This will speed up the transitional effect while the ECG amplifier is switched on.

This process makes the analog part ready to capture the signal. When the time set for detection expires, the SD card write operation is blocked, and the system goes back to the stand-by mode. The proposed operating mode leads to significant savings in energy drawn from the MULTIHOLTER power supply and thus extends the period for which it can operate.

Since this is a mobile device, namely one which for 24 hours or a period specified by the doctor is attached to the patient, it was necessary to resolve the problem of power supply and to minimize power consumption. This affects the size of batteries necessary to power the device. Therefore, electronic components were chosen with the least current.

The circuit design itself has an impact on energy consumption. Further savings in electric power can be obtained by switching all integrated circuits to the stand-by mode.

D. Power supply

To simplify the entire device, non-symmetrical power supply was chosen. Such a solution can be a source of problems when setting the output level of a circuit and the input level of the follow-up circuit. The critical point is the converter input. On the other hand, using the non-symmetrical power supply simplifies the device. For symmetrical power supply it would be necessary to use either two batteries or one battery and a chopper converter (e.g. charge pump). A second battery would significantly extend the size of the entire device, and the chopper converter always brings problems regarding the suppression of undesirable interference, which is connected with its activity. The problem is the larger, the more sensitive amplifier must be powered. Voltage references were used to shift the signal in places where it is necessary for reasons of functionality.

III. CONCLUSION

A MULTIHOLTER device for dual, long-term digital acquisition of electrical signals from ECG and PPG probes was presented. The device allows for approximately 24 hours of operation, and the planned use of voluntary patients is more than safe (powered by a 9V battery) and comfortable. The only inevitable restrictions on the patient (with the exception of the transmission device itself), are the use of ECG and PPT probes, which are mounted on the body using a special healthy sticky surface. After the measuring process, the data acquired will be evaluated on a PC station to seek the context of relations between the stored signals and the blood pressure. After the completion of test and measurement, a methodology for the evaluation of results will be worked out and tested on a sufficiently large number of patients in order to demonstrate the functionality of the methodology on a statistically adequate data set. If the conclusions drawn from analyzed data are positive, the MULTIHOLTER development will continue in order to prepare it for the practical operation. In this case it will be necessary to add to the device some additional features such as AVC, monitoring of sampled signal detection, and appropriate calibration.

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