Heart Rate Measurement System

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Abstract – **In this paper a portable heart rate measurement system is present. This system is low-cost and has low power consumption. It uses optical method by infrared light. Along with measurement capabilities the presented system can record the measured data as well as time, date and year for up to three days. The recorded data can be downloaded from personal computer for further analysis. Also a smart method for LED bias setting is introduced.**

Keywords **– Pulse oximetry, Heart rate, Telemedicine**

I. INTRODUCTION

The pulse oximetry is a non invasive method for oxygen saturation measurement by sensing the infrared and red light absorption properties of deoxygenated and oxygenated hemoglobin. It is comprised of a sensing probe attached to a patient's earlobe, toe, or finger, which is connected to a data acquisition system for calculation and display of oxygen level, heart rate, and blood flow. Deoxygenated hemoglobin allows more infrared light to pass through and absorbs more red light. Highly oxygenated hemoglobin allows more red light to pass through and absorbs more infrared light.

Based on mentioned above method, the presented heart rate recorder uses infrared light to measure the period of AC component, sensed by light to voltage converter, caused by blood flow changing.

The system records the data into serial EEPROM with actual time, date and year.

II. SYSTEM STRUCTURE

According to Figure 1, the main part of the described system is Digital Signal Controller (DSC). The built-in 10-bit ADC samples the amplified pulses and by simple algorithm measures and averages its period. Also it is responsible for exact bias setting of the infrared LED (λ = 940nm) by driving the Digital to Analogue Converter (DAC). This DAC directly sets the LED current. It is necessary to set the correct bias in terms to achieve higher LED current (thus achieving strong signal for measurement) as well as to avoid amplifier saturation. This method is simple but efficient. The 4-bit current DAC is built using four resistors, each of them with resistance twice as resistance of previous (300Ω, 600Ω, 1200Ω and 2400Ω). So the maximum current can be about 20mA and the step is 1.4mA, considering 4.5V supply voltage. Experiments show that proper current is about 8-10mA. A feedback to the DSC, used for correct LED bias maintain is implemented as analogue comparator, which compares the DC level of the light to voltage converter output with a threshold. The threshold is set by divider to be a half of power supply voltage. No hysteresis is necessary for comparator, because it simply interrupts the DSC on achieving proper LED – photodiode bias. The used light to voltage converter is integrated photodiode with operational amplifier, type TSL250R. This concept simplifies the circuit, minimizes the size and reduces the price. The high-pass filter removes the DC component from the signal. Its cut-off frequency is set to 0.3Hz which corresponds to 20-30 beats per minute (lowest measured pulse). Because it is necessary to measure only the period of the waveform, a single supply operational amplifier with gain = 100, amplifies the positive half of signal. A low-pass filter removes high frequency components, thus ensuring correct ADC operation. A Real-Time Clock (RTC) with date and year maintain capability is implemented in DSC. The measured heart rate along with time/date is recorded into serial EEPROM, connected via SPI interface to the DSC. Later this recorded data can be downloaded from a PC through rs-232 interface. The measurement interval as well as time/date adjusting can be configured via rs-232 also.

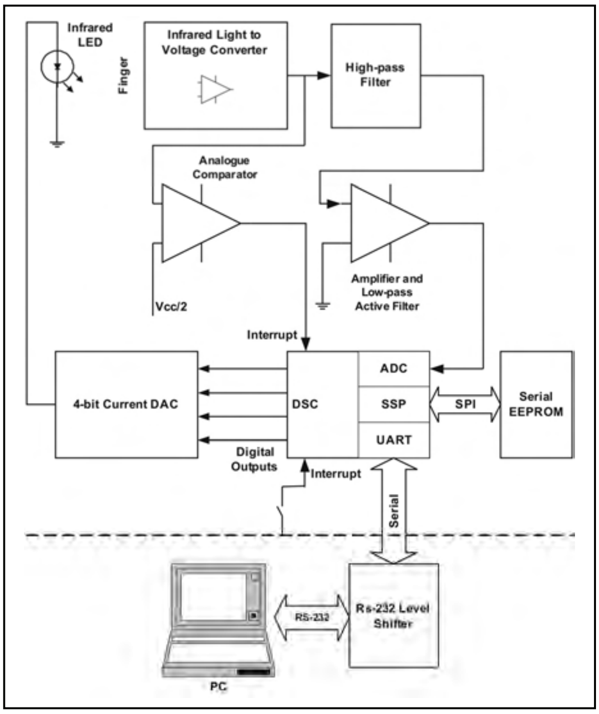

Fig. 1. System structure

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In order to reduce the power consumption the LED is turned-on only in the process of measurement. The duration of this measurement is no more than 20s. The DSC uses SLEEP capability (low power mode). It wakes only on Real Time Clock update, or when the device is connected to the PC.

A serial 4kByte EEPROM with SPI interface is used to store the measured data. All data is in ASCII format, excepting the measured pulse which is recorded in one byte.

III. EXPERIMENTAL RESULTS

Figure 2 shows a chart of the sampled pulse waveform. As can be seen the period measurement can be made by zero-cross detection.

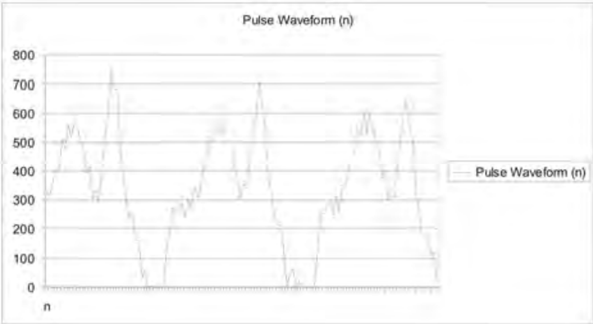

Fig. 2. Pulse waveform

A simple terminal program is used to configure the recorder and to read the recorded data. In figure 3 are shown downloaded sample results of heart rate measurement and recording. First column is year-month-date, the second is time and the third one is the recorded heart rate.

65535		
2006-08-21	03:18:36	100
2006-08-21	03:18:48	96
2006-08-21	03:19:00	98
2006-08-21	03:19:12	100
2006-08-21	03:19:24	93
2006-08-21	03:19:36	97
2006-08-21	03:19:48	97
2006-08-21	03:20:00	96
2006-08-21	03:20:12	101
END		

Fig. 3. Sample results of heart rate measurement

IV. CONCLUSION

In this paper a heart rate measurement system is described. As mentioned above, the system is low-cost and has low power consumption. The future work will be to minimize the influence of external light interference. By using DSC with more resources, it will be possible to achieve better results, if the period is measured not directly from the signal, but from previously calculated Auto Correlative Function (ACF). Despite of presented noise the ACF is still periodic with period matching to the period of the investigated signal. By knowing the position of the absolute maximum of the ACF and finding the position of the second peak, measuring the period won't be difficult.

In addition a synchronous detection method can be very suitable for this system.

In other hand it will be useful to turn this system into pulse oximetry measuring and recording system just by adding a second red LED and red light sensor.

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