Heart Rate Extraction Hardware from ECG Data

M. Nii[1,2,3], T. Tanaka[1], Y. Matsumoto[1], T. Bartley[2], U. Maksudi[2], O. Nizhnik[2], K. Sonoda[1], H. Takao[2,4], K. Maenaka[1,2], and K. Higuchi[2], *Member, IEEE*

***Abstract*— In the conventional MEMS based human activity monitoring device, the heart rate (HR) extraction has been performed in the micro processing unit (MPU). To reduce the power consumption at the monitoring device, we construct a circuit specialized to extract HR. MPU can receive not raw ECG data but calculated HR. MPU can sleep until at receiving the next HR. Our HR extraction circuit is sufficiently smaller than MPU. Therefore, the power consumption at the monitoring device is reduced.**

I. Introduction

Daily activity recording is important for us to recognize and maintain our health by ourselves. For realizing the daily monitoring, MEMS based device has been developed [1, 2]. The monitoring device has several types of sensors such as acceleration sensors, a pressure sensor, a humidity sensor, and ECG monitoring. While the monitoring device can record human activity data by using several types of sensors, we need to tackle a power consumption problem. Such a monitoring device is demanded that it can be attached to human body for long continuously. However, there is a tradeoff between power source size and provided power. Therefore, we need to reduce the power consumption for keeping small enough size of the power source.

II. Heart Rate Extraction Circuit

Heart rate extraction is performed by MPU in the conventional monitoring device. MPU receives raw ECG data to calculate HR. Hence, MPU has to be always active. HR is calculated from R-R interval. R-R interval is the time interval between a single R wave and the next R wave. If MPU receives not raw ECG data but R-R interval, then MPU can sleep between an R-R interval and the next R-R interval. The output cycle of R-R interval is longer than ECG sampling (125Hz).

In order to design a small and simple R-R interval detection circuit, we proposed the following algorithm.

$$\text{If } AMP_{\text{MAX}} < h_1 \text{ and } T_{\text{MIN}} < t_1 < T_{\text{MAX}} \text{ then QR,} \quad (1)$$

$$\text{If } AMP_{\text{MAX}} < h_2 \text{ and } T_{\text{MIN}} < t_2 < T_{\text{MAX}} \text{ then RS,} \quad (2)$$

where AMP_{MAX}, T_{MIN}, and T_{MAX} are threshold values. Figure 1 shows h_1, h_2, t_1, and t_2. Using these two rules, we can find R wave. Since we can find R wave without multiplier by using these two rules, our R-R interval detection circuit is simple and small.

Figure 2 shows a prototype of our R-R interval detection circuit. Our circuit was laid out on upper left of this ASIC. This prototype is still large ($195 \times 182\mu m^2$, 1920 gates). Currently, we have ordered the next prototype to UMC. The core size of newer prototype is $150 \times 140\mu m^2$ and the number of gates is 774. Its dynamic and leakage power are 20.5 nW and 6.7 nW respectively. Figure 3 shows R wave extracted by using Fig.2 prototype. From this result, our R-R interval detection circuit worked well with small power.

III. Conclusion

We proposed and constructed HR extraction hardware. Our circuit specialized to R-R interval detection was enough small and detects R wave accurately.

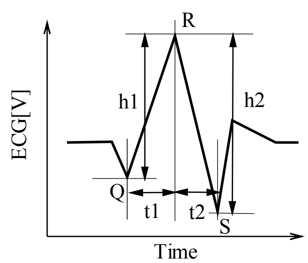

Figure 1. Parameters.

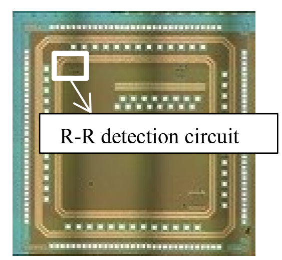

Figure 2. Prototype.

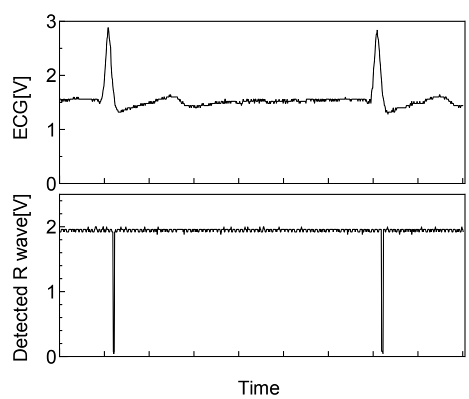

Figure 3. Extracted R wave.

1. Dept. of EECS, Graduate School of Engineering, University of Hyogo, 2167 Shosha, Himeji, Hyogo 671-2280, Japan (corresponding author to provide e-mail: nii@eng.u-hyogo.ac.jp).

2. Maenaka Human Sensing Fusion Project, ERATO, Japan Science and Technology Agency 2167 Shosha, Himeji, Hyogo 671-2280, Japan.

3. WPI Immunology Frontier Research Center, Osaka University, Suita, Osaka, Japan.

4. Kagawa University, Saiwaicho 1-1, Takamatsu City, Kagawa Prefecture 760-8521, Japan.

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