A System Prototype for Portable Wireless Medical Devices*

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Abstract – **This paper presents a system prototype for portable wireless medical devices. An ASIC possessing physiological signal sensing is included. A multi-parameter communication protocol is employed to provide various functions and operation modes to satisfying different applications. LSK (load shift keying) is adopted to carry out no-battery wireless communication. The proposed design can be easily modified in implantable application if appropriate bio-compatible packaging is utilized.**

Key word : wireless, medical device, low power, sensing, LSK

I. INTRODUCTION

Traditionally, physicians might reply on *in vitro* signal acquisition instruments and spectral analysis to detect electro-physiological signals in living tissues, e.g., skin-surfaced electrodes and pads, amplifiers, filters, etc. Then, physicians can evaluate the health condition of the patients by the readings of heart and lung sounds, arterial blood pressure, and variation of temperatures. Such medical treatments have been drastically improved by the advance of modern sciences and technologies lately, particularly the evolution toward the nano-scale semiconductor process. One of the astonishing therapeutic tools is the portable medical devices. The sensing of vague physiological signals and the recording thereof allow that the portable medical devices can be a part of a neuroprosthesis. However, these signals possess low signal amplitude, e.g., in the range of 1 to10 mV, and low frequency in the spectrum between 100 Hz to 7 KHz. We, thus, explore the possibility of utilizing the nano-technology and wireless communication to faithfully sense physiological signals directly such that portable medical devices will be available to every person who needs.

II. AN ASIC FOR A PORTABLE SYSTEM

A. System View for Neural Signal Sensing

Fig. 1 depicts a generic model for a wireless miniature sensing system. The basic building circuits include electrodes, an IA (instrumentation amplifier with high gain and high CMRR), an ADC (analog-to-digital converter), a PtoS (parallel to serial converter), a LSK (load shift keying) modulator, and a coil. Notably, the LSK modulation is triggered when the triggered when the external device with power supply is nearby. Thus, the internal module can be no battery at all, which can be further implanted in a live subject if needed.

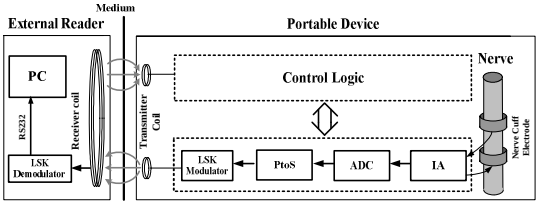

Fig. 1. A generic system model for physiological sensing

- IA : It must be a high gain ($\geqq$ 500) amplifier at a low bio-frequency band ($\leqq$ 7 KHz) so as to conquer the difficult of picking up the bio-signals, since these signals (or called biopotential) is usually in the band 10 ~ 7K Hz merely with a 10 mV amplitude or even smaller.
- ADC : Sub-1 V ADCs are very much preferred in such systems, because the supply voltage thereof will head for 1 V in the nano-technology process. Notably, the design of sub-1V ADC will encounter the problems of reduced head room and severe leakage.
- LSK modulator : It is foreseeable that the both the coil and the passive elements of the implants must be small to be physically implantable. What even worse is that even if there is a battery to supply the power to the system, the over transmitting power is still really small. LSK has been recognized as one of the most feasible scheme to deliver the sensed signal in a digitized format to the external reader. Fig. 2 reveals a possible wireless scenario between a portable device and an external reader.

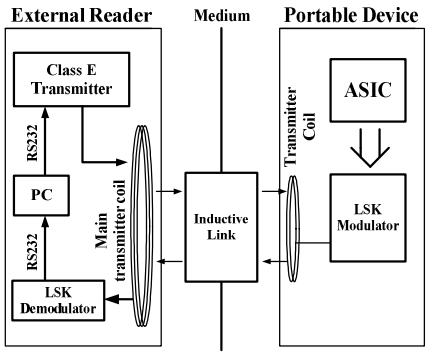

Fig. 2. Wireless interface between the device and the external reader

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B. *Ultra-low Power Management*

Power management would be one of the most critical factors to determine whether a wireless bio-sensing system is a success or a failure. Besides using a tiny battery cell, a no-battery implanted system is considered feasible. We tend to adopt an RFID-like power scheme as shown in Fig. 3 to resolve the power problem [1].

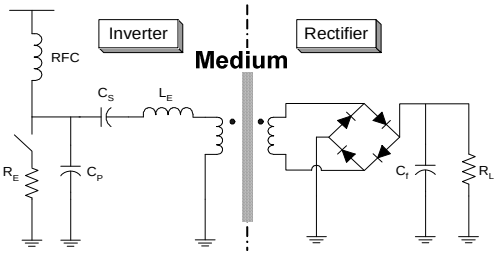

Fig. 3. RFID-like power supply

C. *Body Area Network (BAN)*

A bold assumption is that more and more portable medical devices will be either implanted or carried by a living body in the future as shown in Fig. 4. The scenario of the BAN is more complicated than the existing homecare system [2], since the wireless signals are transmitted around a human body instead of in a house. Their missions of BAN might cover monitoring, or recording certain physiological signals, or activating some other medical devices such as micro-stimulators, pacemakers, or actuators [3]. However, since there are more than one device around the living body, a wireless network is then formed, namely, Body Area Network (BAN). However, possible mistakenly actions might be caused when there is no proper coordination mechanism among these biochips. For instance, a pacemaker might be accidentally triggered to generate unwanted pulses, which might cause uncomfortable feeling or dangerous consequences.

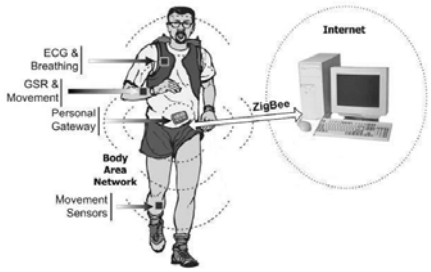

Fig. 4. The wireless portable systems in the BAN

Besides the individual devices, a Personal Gateway (PG) and a communication protocol is required to coordinate with a remote host. The RF link between the PG and the host can employ a low power protocol, e.g., ZigBee. In BAN, a problem which needs to be resolved is the collision, including the tag collision ("tag" denotes the implanted bio-implant in RFID terminology.) and the reader collision (for Personal Gateway) [4]. The tag collision occurs when multiple tags respond to a reader's (Personal Gateway's) request of activating a device. The reader collision occurs when the reader (Personal Gateway) cannot distinguish the response coming from which tag. The reason is because the same frequency band might be used for a few tags. It causes the crash on the signals. Techniques to avoid the mentioned collisions when multiple portable devices are used will be studied shortly in the future.

註解 [I1]: We probably should say a few more words why RFID power supply might provide a good starting point. Have we considered other power management methodologies in the sensor network area?

III. Implementation and Measurement

To support of the establishment of the BAN, we have accomplished the prototype of a wireless portable device as shown in Fig. 5. Notably, we only solder the components on one side of the PCB for sake of easy probing signals. In fact, the overall size could be smaller than 1/4 of one coin.

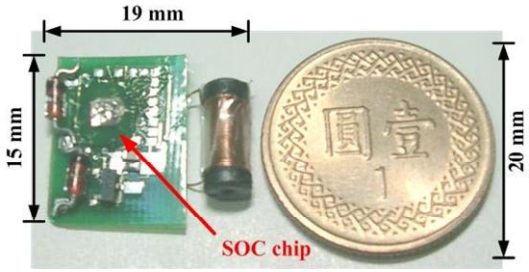

Fig. 5. Prototype system of the portable medical device

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註解 [I2]: Perhaps we shall include the concern for security and/or privacy related issues here.

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