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Design and Implementation of a High Integrated Noncontact ECG Monitoring Belt ⋆

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Abstract

The ECG plays a key role in the rapid diagnosis of heart diseases such as coronary heart disease, ischemic heart disease, myocardial infarction, arrhythmias, etc. Unfortunately, the adhesion of conventional electrodes to the skin sometimes is difficult if not impossible due to the wet skin caused by higher perspiration. Besides, for the application of long term ECG monitoring, the wet adhesive ECG electrodes are easy to cause infection of the wearers' skin. Moreover, in certain situations it is difficult or simply too time-consuming to undress the patient for an ECG. Therefore, novel ECG monitoring techniques are urgently needed. In this paper, an easy-to-use noncontact ECG (NCECG) monitoring node for wireless body sensor network was designed and tested. The NCECG node introduced in this paper use the doubled shielded active ECG electrodes, compared with many other two electrodes noncontact ECG monitoring node, it also added a right-leg-drive circuit to reduce the common mode noise. The experiment result shows that it could accurately monitor the ECG signals while insulated by one layer of clothes. Furthermore, the NCECG monitoring node we proposed is high compact and easy to use. Besides ECG monitoring function, it also integrates with temperature, respiration and motion state monitoring function, while the size of the circuit board is just 93×40 mm. And the elastic belt architecture makes the ECG monitoring much more convenient and easy to use.

Keywords: Active Electrodes; Double Shielded; ECG Monitoring; Wireless Body Sensor Network

1 Introduction

With the improvement of the living standards, people are paying more and more attention to their health. The development of the Body Sensor Network (BSN) technology makes it possible to continuous monitor physiological parameters such as Electrocardiograph (ECG) [9], respiratory rate, Electroencephalograph (EEG) [12], arterial oxygen saturation [13], skin temperature, etc, for a long time.

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The Electrocardiogram (ECG) is a measurement of the electrical activity of the heart over time, captured and externally recorded as measured by various kinds of ECG electrodes. The signals could tell the overall health condition of the heart, the weaknesses in different parts of the heart muscle could be diagnosed in time [1]. This technique is the best way to measure and diagnose abnormal rhythms of the heart, and is commonly used in hospitals all over the world. It is also used in sports and military environments for advanced diagnostics of healthy individuals [14].

Various kinds of electrodes have been used to sample the ECG signal, and the electrodes that are most commonly used to monitor Electrocardiogram (ECG) are gel-type silver/silver chloride (Ag/AgCl) electrodes. Although such electrodes have been widely used, they are limited in their long-term usage because they usually cause irritation to the skin [3]. Moreover, the gel also dries over time, which will cause a dramatic decrease in the signal quality. Additionally, signal noise is enhanced by the space charge layer at the interface between the skin and the electrode paste. Besides, sweat is another source of signal degradation [4].

Noncontact ECG measurement (NCECG) is a newly developed method that does not require any direct contact between the device and the human skin. And the basic principle of the noncontact measurement of the ECG signal is the capacitive coupling between the skin and a metallic face inside the sensor. These electrodes are placed close to the skin with an insulating material between the electrodes face and the skin. An ultra-high input impedance amplifier is connected to the metallic face to guarantee a low input corner frequency below 100 mHz and a high-input-impedance above 50 GΩ for the capacitive coupled bio-signal.

Nowadays studies on bio-signal electrodes are many and lots of new types of ECG monitoring electrodes are designed and proposed. Ha-Chul Jung et al. described the fabrication of the PDMS/CNT flexible dry electrodes for long-term ECG monitoring in [5], this kind of electrodes have the advantage of flexible and comfortable for the wearers, nevertheless the electrical property can be affected by many factors such as the density of the CNT, the fabrication techniques, etc. Micro needles designed for bio-signal extracting is described in [2] by Patrick Griss, this kind of electrodes through have comparatively low contact impedance, while, as this kind of electrodes need to insert into the skin, it may cause pain to the wearer whose stratum corneum is thin. Carbon Nanotube (CNT) array designed by Giulio Ruffini in [7] is an improvement method of micro needle. Through the CNT array has wonderful electrical performance and is comfortable for the patient to wear, but the fabrication process of this kind of electrodes is complex. Another kind of dry electrode used in many studies is the active electrode [6], the active electrode is usually consist of a preamplifier circuit and an active shield. This kind of electrode is easy to fabricate and has relatively better signal acquiring performance, so the active electrodes are designed and used in our work.

The main contribution of our work is the design of a noncontact ECG monitoring wearable chest belt which makes it possible to continuous and long-term monitoring of people's health conditions at anytime and anywhere and without causing irritation. Besides, compared with the studies of other noncontact ECG monitoring nodes, the NCECG node we designed has the advantages of small size, low power consumption and easy to use, etc. In order to reduce the common mode interference, a Right Leg Drive (RLD) circuit with the RLD electrode was integrated in the back of the circuit board which could reduce wires to some extent. The picture of the NCECG monitoring belt node is shown in Fig. 1.

The rest of this paper is organized as follows: In Section 2, the design of the double shielded active electrode was introduced. In Section 3, the hardware design of the NCECG belt was de-