Electrode Characteristics of Non-contact Electrocardiographic Measurement

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The ability to take electrocardiographic measurements while performing our daily activities has become the people-choice for modern age vital sign sensing. Currently, wet and dry ECG electrodes are known to pose threats like inflammations, allergic reactions, and metal poisoning due to their direct skin interaction. Therefore, the main goal in this work is to implement a very small ECG sensor system with a capacitive coupling, which is able to detect electrical signals of heart at a distance without the conductive gel. The aim of this paper is to design, implement, and characterize the contactless ECG electrodes. Under a careful consideration of factors that affect a capacitive electrode functional integrity, several different sizes of ECG electrodes were designed and tested with a pilot ECG device. A very small cotton-insulated copper tape electrode (2.324 cm²) was finally attained that could detect and measure bioelectric signal at about 500 um of distance from the subject’s chest.

Keywords: Electrocardiogram, Electrophysiological, Bio-potential, Capacitive electrodes, Capacitive coupling

1. INTRODUCTION

While valuable time and money is being pumped into disposable wet electrocardiographic (ECG) electrodes every year, they still demand a long time on skin preparation making the procedure not suitable for a long term acquisition. They also pose comfortability issues like irritation, inflammation, and allergic reactions due the toxicological issue of the gel during prolonged use [1]. Moreover, in a situation where the wet electrode becomes separated from the skin or when gel dries out, it is no longer effective to pick-up biosignal with the required fidelity. This situation is mostly common in electrophysiological measurement of neonates who are usually moving during an ECG procedure.

Even though the current wet ECG devices have impedance sensors for sensing electrode contact loss, neither the loss data is recovered nor is the operation of the system resumed [2]. These issues of wet ECG electrodes led to the invention of dry electrode. Dry electrodes do not require gel for bio-signal acquisition, but they also have issues such as poor electrode-skin contact and metal poisoning. A good contact is established by dry electrodes after perspiration, where the sweat acts as the electrolyte at the skin-electrode interface. There are two kinds of dry electrodes, namely stiff and flexible electrodes. Stiff electrodes have the tendency to slip over the skin during any slight movement, which may cause loss in electrode contact and some charging effects between the electrodes. Flexible electrodes are soft and have the ability to lie flat on the body surface; hence, they have a relatively higher contact area than stiff electrodes [3]. Both wet and dry electrodes experience huge distortion of electrophysiological signals during a high physical activity, due to the relative motion between electrodes and skin. The idea of measuring bio-signal without skin contact led to the evolution of another