

# Chapter 1

## A Wearable ECG Monitoring System for Resource-Constrained Settings

**Uma Arun**

*Center for Medical Electronics and Computing, M. S. Ramaiah Institute of Technology, India*

**Natarajan Sriraam**

 <https://orcid.org/0000-0003-3790-3900>

*Center for Medical Electronics and Computing, M. S. Ramaiah Institute of Technology, India*

### ABSTRACT

*Recent advancement in wearable technology has created a huge impact in healthcare delivery and clinical diagnosis. Remote access of physiological, vital parameters from patients and improvement in their day-to-day quality of life were the significant indicators due to this availability of wearable technology. Though wearable physiological monitoring systems for long-term monitoring of Electro cardiogram (ECG) were developed at high-cost involvement, there is a huge need for such technology for resource-constrained settings, at a low cost. This chapter suggests a wearable ECG monitoring system by making use of single channel textile sensors for screening of cardiac episodes. The proposed Cardiac signal framework (CARDIF) with chest textile-based sensors ensures the required qualitative signal for clinical assessment and the evaluation of fidelity measures confirms its suitability for early screening of cardiac episodes. The proposed CARDIF framework involves low-cost design without sacrificing the required clinical diagnosis requirement and can be extended for long-term, continuous monitoring in resource-constrained settings.*

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## **INTRODUCTION**

Cardiovascular diseases (CVDs) tops the foremost reason for death all over the world according to the survey reported by World Health Organization (WHO). In 2018 million people died due to CVDs, Stroke and coronary heart diseases contribute significantly for the cause of death. Hence there is a huge need to monitor cardiac activities continuously and to identify the potential risk at an earlier stage. Wearable technology and computing showed a promising clinical diagnosis tool due to its ability to monitor the physiological vital parameter continuously as well as for long-term monitoring.

For Biomedical research community, design and developing ubiquitous physiological monitoring system for resource constrained settings is quite challenging. Electrocardiogram (ECG) signals are considered as the vital biomarker to assess and monitor the cardiac activities. Heart and circulatory system disorders are the major causes of death all over the world according to World Health Organization (WHO) (Kirstein .T. et al.,2002). The main reasons are obesity, intensive consumption of salty and oily foods, stress, lack of exercise and genetic factors. The number of cardiologists per patient having heart disease is very less. Due to this, the heart-related diseases increase and mortality rate is very high. Long-term monitoring and consistent medical observation could help in reducing mortalities (Rantanen et al., 2001). Keeping in mind the importance of heart rate variability towards assessing the cardiovascular-pulmonary functionalities, wearable mode gains its importance for home centric applications.

The development of gel less textile-based electrodes gained importance in the recent years for wearable computing applications due to its rapid conductive properties between the skin surfaces and less prone to artifacts motion. The selection of textile materials for such application merely depends on the material's durability, reusability and launder ability (Grancaric et al., 2017).

In recent years, many wearable physiological monitoring systems are being used for real-time healthcare monitoring. The wearable systems combine high-tech components and wearable devices. The smart wearable system includes sensors, actuators and communication equipment. Early detection of vital conditions of patients is possible using these wearable healthcare systems (Norstebo et al., 2003)

Electrocardiogram is a bio-signal from which the electrical action of the heart is observed. ECG measurements are performed using Ag/AgCl electrodes.(Constant .J et al.,1997) (Uma Arun et al.,2016). But these electrodes are not used directly as contact cannot be maintained with skin (Pola & Vanhala). So, conductive gel was applied to patients before attaching Ag/AgCl electrodes. These electrodes create an itching sensation on the skin during long-term usage. Other issues were that the

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