# WEARABLE WIRELEDD RFID FOR HEART RATE MONITORING


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**Summary:** Radio Frequency Identification (RFID) is one of the many emerging technologies that are part of many industries. It uses electromagnetic fields attached to any tags to identify and track objects. This technology has seen significant growth seen in its applications in the medical industry, which has its emphasis on patient safety.Wireless heart monitoring is a technology that can save lives and restore peace of mind to those with heart disease and those at-risk. Heart disease is the most prevalent health problem in the United States currently. The RFID technology has not had a major role in cardiac healthcare systems; however, it is an ideal technology for wireless heart monitoring devices. Remote healthcare monitoring allows people to continue to stay at home rather than in expensive healthcare facilities such as hospitals or nursing homes. It thus provides an efficient and cost-effective alternative to on-site clinical monitoring. Such systems equipped with non-invasive and unobtrusive wearable sensors can be viable diagnostic tools to the healthcare personnel for monitoring important physiological signs and activities of the patients in real-time, from a distant facility. Wearable RFID tags can monitor and record real-time information about one's physiological condition and motion activities. Wearable sensor-based health monitoring systems may comprise different types of flexible sensors that integrated into textile fiber, clothes, and elastic bands or directly attached to the human body. The sensors are capable of measuring physiological signs such as electrocardiogram (ECG), electromyogram (EMG), heart rate (HR), body temperature, electro dermal activity (EDA), arterial oxygen saturation ($SpO_2$), blood pressure (BP) and respiration rate (RR). Continuous monitoring of physiological signals could help to detect and diagnose several cardiovascular, neurological and pulmonary diseases at their early onset. In addition, real-time monitoring of an individual’s motion activities could be useful in fall detection, gait pattern and posture analysis, or in sleep assessment.



**Key words:** RFID, tags, radio frequency.


## INTRODUCTION

Radio Frequency Identification (RFID) is being widely adopted in the medical field to track objects and people in order to increase efficiency and safety. There was considerable interest in the use of RFID in the operating theatre as part of a widespread computer system. Previous work has also identified an attempt to use Auto-Identification as part of a project for the automated detection of anesthetic activity. An optimal range of heart rates for exercising exists for each person. Athletes need to exercise in their optimal heart rate zones to effectively train. People with heart disease also need to stay in a safe heart rate zone. An emergency contact enabled mobile cardiac monitor would help these users exercise effectively and safely. It could also save their lives if, for example, they had a heart attack while exercising.

## METHODOLOGY

This work analyzes and discusses the application of the RFID technology with primary focus of its usefulness in the biotechnological field. It presents the possible expenditures and results that this study could lead up to in the renovating field along with the advantages that RFID brings with.

## DISCUSSION

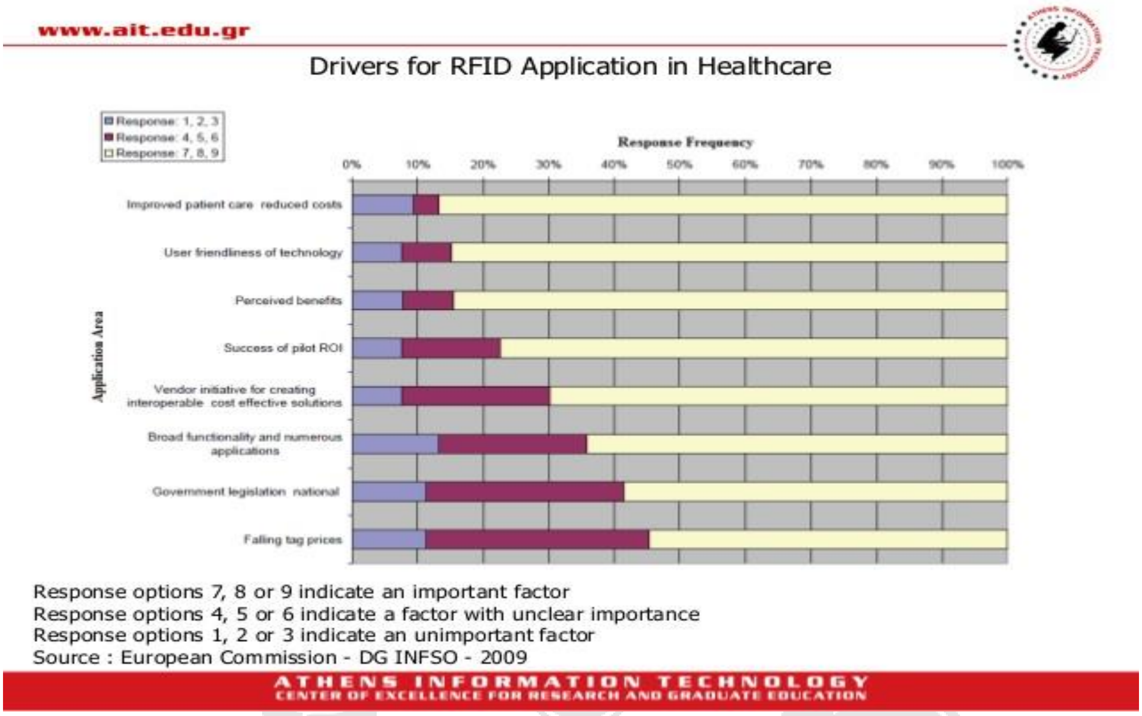
In accordance with Parry (2014), anesthetics safety is a continuing area of concern, and anesthetic workload is a particular area for research and improvement. The concern is that clinical errors are more likely to occur when clinical workload is high, and that anesthetic spaces must be designed so that the anesthetist and anesthetic technician and other staff can work efficiently and calmly even during high-workload events. Laboratories can use RFID products to track tissue or fluid samples.

As samples move through various preparation steps, they can be automatically tracked, reducing errors from data entry or mishandling. Samples that arrive at the pathologist for analysis will automatically have the patient record and the indication called to the computer screen to ensure proper association of the sample with the patient. RFID product tags can be used to track and locate medical devices. The use of RFID products on equipment and RTLS (Real time locating systems), enables hospital staff to rapidly locate critical medical devices. When you need a defibrillator, you need to locate it fast. This enhances patient safety, and can reduce the amount of equipment investment needed, as induced by Houliston (2011).

Additionally these tags can be used to inventory equipment and consumables used in an operation, including scalpels, sponges, clamps and other surgical equipment. At the end of an operation everything can be automatically accounted for.

Figure 1 shows the graph representing some of the statistics behind the drivers for the usage of RFID in the medical industry. As shown, it is highlighted some of the important factors that have led for the growth of this technology on the field.

**Figure 1**: Drivers for RFID Application in Healthcare Figure 1: Drivers for RFID Application in Healthcare



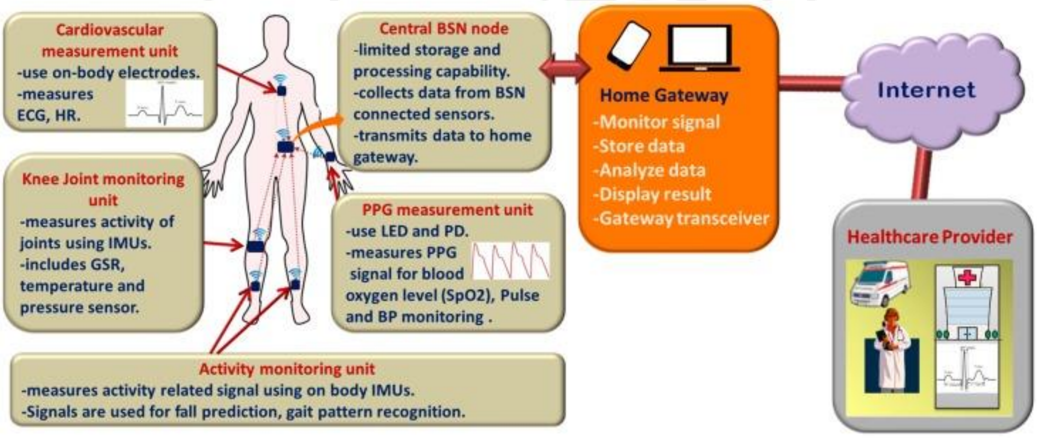

**Fonte**: AIT (2009)

In accordance with Hopkins (2009), an optimal exercise prescription is a balance between the frequency, intensity, duration, and mode of exercise. Heart rate is a useful indicator of the intensity of effort and body's physiological adaptation. Heart rate monitoring is an important component especially in cardiovascular fitness assessment and training programs.

The measurement of heart rate variability (HRV) distinguishes as a convenient non-invasive assessment tool for monitoring individual adaptation to training. Decreases and increases in vagal-derived indices of HRV indicate negative and positive adaptations, respectively, to endurance training regimens. However, much of the research in this area has involved recreational and well-trained athletes, with the small number of studies conducted in elite athletes revealing equivocal outcomes. For example, in elite athletes, studies have revealed both increases and decreases in HRV to be associated with negative adaptation. Additionally, signs of positive adaptation, such as increases in cardiorespiratory fitness, are associated with atypical concomitant decreases in HRV. As such, practical ways by which HRV can monitor training status in elites are yet to be established.

Tele-cardiology through RFID-based wireless sensor networks can provide anytime cardiac patient monitoring in large nursing homes. Wireless medical sensors and PDA devices can provide continuous transmission of patients' cardiac data (such as ECG, blood pressure, SpO2, etc.), as shown in figure 2:

**Figure 2**: General overview of the remote health monitoring system

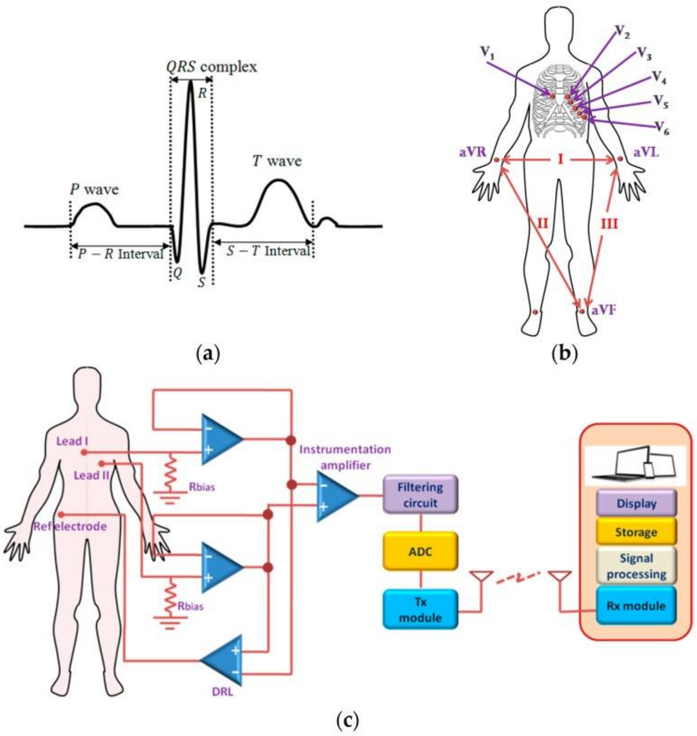



**Fonte**: Majunder et al. (2017)

Electrocardiograms (ECGs) represent a non-invasive approach for measuring and recording the fluctuations of cardiac potential. This is the most widely used and effective diagnostic tool that physicians have used for decades to identify heart-related problems such as different forms of arrhythmias. Although many arrhythmias are not life threatening, some results from weak or damaged heart such as myocardial infarction (MI) that may lead to cardiac arrest, if not managed immediately. After a heart attack, patients are required to receive immediate medical attention, which, otherwise, may turn fatal. These complications reduce if any inconsistency in cardiac activity is detected and treated in an early stage that calls for outpatient ambulatory monitoring of ECG.

In the figure 3, (a) shows one cycle of a typical ECG signal. In a conventional 12 lead ECG system, electrical activities of the heart along 12 particular spatial orientations are measured using ten Ag-AgCl electrodes (hydrogel method/wet ECG), which are affixed to some specific parts of the body. Following,(b) shows the placement of the electrodes in a standard of 12-lead ECG system. The electrodes contain conducting gel in the middle of the pad that functions as a conduction medium between the skin and the electrode. However, only a few numbers of electrodes are used in ambulatory ECG monitoring system at the cost of limited information (c). A continuous ambulatory monitoring device requires a wearable and portable system that could be used comfortably without affecting an individual's daily activities.

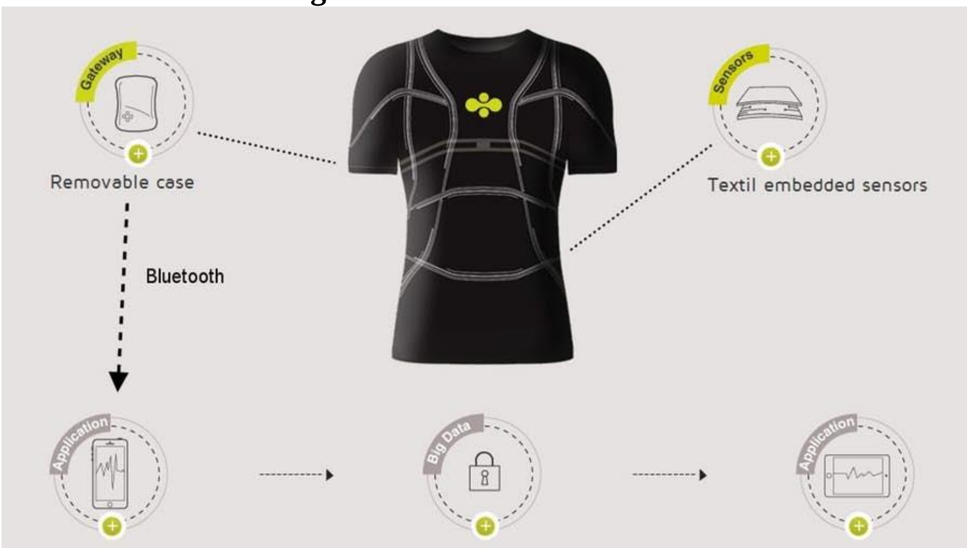
**Figure 3:** Cardiovascular Monitoring




**Fonte:** Majunder et al. (2017)

Andreoni et al. designed a custom T-shirt, shown in figure 4, and textile belts with embedded textile electrodes for monitoring ECG, HR, and R-R interval. The electrodes are made from silver-based conductive yarns. Instead of using any conductive gel, the electrodes relied on body sweat, an electrolyte medium, to improve the conductivity of the skin-electrode interface and signal quality. The device also included a $SpO_2$ sensor and a three-axis accelerometer for fall detection. An elastic fabric-made ECG vest was presented in which accommodated three electrodes, a data acquisition module and also supported robust contact of the electrodes with the skin. The electrodes were fabricated from Ni/Cu coated compressed urethane polymer foam that was enclosed by an Au-coated conductive taffeta fabric.

**Figure 4:** Wearable HRM Shirt




**Fonte:** Andreoni et al. (2017)

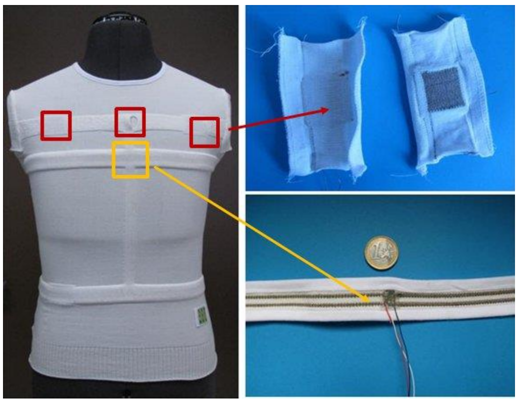
Jeong et al. proposed an ECG monitoring system where they used similar technology as to develop flexible capacitive electrodes and integrated them in a chest belt, as seen in the figure 5. In addition to that, they used a very high bias resistor at the input of the pre-amplifier, which assisted further in reducing electrode motion artifacts. A noise cancellation and peak detection algorithm was performed on the raw ECG data to find out the QRS complex, and HR.

**Figure 5**: HRM Chest Belt

**Fonte:** Jeong et al (2014)

Moreover, the electrodes used in these ECG systems mentioned presented in were in direct contact with the skin. Nemati et al. embedded a small, low–power, wireless ECG monitoring system in a stretchable belt where three capacitive electrodes (Figure 6) were integrated into a cotton T-shirt, thus enabling ECG measurements to be performed over the cloth. The cotton functioned as the dielectric material between the electrode and the skin. The signal processing and communication modules were mounted on a small two-layer PCB board. Power consumption was minimized by selecting low power electronic components for the system, ANT protocol for wireless communication as well as by adopting idle mode signal sampling technique.

**Figure 6**: HRM Cotton Shirt



**Fonte**: Nemati et al. (2012)

Active RFID is a perfect wireless technology for this application due to its range and bandwidth.The physiological signals measured by the on-body sensors need a two-stage communication to transmit the data to the remote healthcare server. In the first stage, a short-range communication protocol is employed to transmit the measured data to a nearest gateway node such as PDA, smartphone, computer, custom-designed FPGA, or a microcontroller-based processing board. The gateway is responsible for advanced data processing, display, and the next long range communication stage, where the processed signal is transmitted to a distant server placed in a healthcare facility.

In the case of short-range communication, the sensors can communicate to the gateway directly over a wireless medium. Alternatively, the sensors can form a body sensor network (BSN), a star network topology and send data to the central BSN node. The BSN node sends data to the gateway after performing some processing. The on-body sensors and the BSN node communicates by using wired or wireless medium. However, wired connections can hinder the users' mobility and may cause frequent failed connections. Thus, they are not suitable for wearable and long-term monitoring systems. A good option is to use conductive fabric yarns as the alternative conductive medium. These fabrics can easily integrate into clothing to communicate with textile-embedded sensors. As discussed earlier, the conductive fabric can be fabricated using conventional textile technologies such as weaving, stitching, embroidery, and printing. However, conductive fibers do have a problem due to their low durability and wash ability that may lead to poor or failed connectivity after a long period of use. Therefore, wireless technology can be adopted as the most viable and reliable alternative for short-range communication.

Bluetooth is a popular low power RF communication technology that has been widely used in devices such as laptops, smartphones and fitness trackers for short-range data communication. It uses the 2.4 GHz frequency band in the industrial, scientific and medical (ISM) radio spectrum and transmits signal over 79 designated channels using the Frequency Hopping Spread Spectrum (FHSS) method. The FHSS method is less susceptible to noise and interference and offers highly secured data transmission. One master device can communicate with seven slave devices thus, forming a star type network structure based on Bluetooth connectivity (Piconet). The master defines the clock and hopping sequence for the whole Piconet. The Bluetooth technology can support a data rate of ~3 Mbps depending on the modulation schemes, although the maximum throughput may only reach ~2.1 Mbps. For general applications, the transmission distance typically ranges from 1 m to 10 m. An ultralow-power version of Bluetooth technology, named as Bluetooth low energy (BLE) or Bluetooth V4 later introduced for portable and wearable devices with limited battery capacity. BLE uses the same frequency band as classical Bluetooth technology but hops over 40 channels with each channel having a bandwidth of 2 MHz. BLE, as the name indicates, offers low power (~10 mW) wireless connectivity and, thereby is a strong candidate for short range communication in long-term monitoring systems.

ANT is a proprietary protocol stack designed for ultra-low-power, short-range wireless communications in sensor networks, especially for health and fitness monitoring systems. It ensures low power consumption by using low data rate, shorter delay cycles, and deep-sleep mode and can operate for longer periods, for example, it can run a year on a 250-mAh coin cell battery. Similar to other wireless protocols presented above, it also operates in the 2.4 GHz ISM band. It uses TDMA (time division multiple access) to communicate with multiple nodes over a single 1 MHz channel.It can switch channelsifanyinterferenceoccurs.

RFID is another popular wireless technology that is widely used primarily for tracking and identification purposes. RFID technology uses different frequency bands including the ISM band. A reader or interrogator sends a signal to a tag or label that is attached to an object to be identified.

## CONCLUSION

The implementation of RFID products in medical applications is reaching maturity in many areas. Reduction of data entry errors, automation of work and information flows, improvement of asset and consumable inventories and better association of treatment plans with patients are all benefits of RFID products in the medical field. The results are better patient outcomes and lower costs. It is clear that established applications will continue to grow and that new applications will emerge for RFID products in the medical arena.

The primary purpose of a wearable health monitoring system is to allow people to lead independent and active lives in their familiar home environment while ensuring continuous, non-invasive, non-intrusive, and seamless surveillance of their health and physical well-being. The enormous development of technology in the past few decades leads to manufacturing and use of miniature, low-power, low-cost sensors, actuators, electronic components, and powerful computers that paves the way to non-invasive, non-intrusive, and continuous monitoring of an individual's health condition at a very low-cost.Continuous monitoring of health status can provide comprehensive information about individuals' health status over a period of time. The wearable sensors and actuators, coupled with the advanced information and communications technologies have opened the window to a new era of cost-effective remote healthcare services.

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