



## CHAPTER 3

# MEDICAL MONITORING WEARABLE TECHNOLOGY

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### ABSTRACT

*A medical wearable technology was designed with all the electronic devices needed for the smartwatch to perform medical monitoring functions such as body temperature sensing and heart rate sensing. The medical smartwatch requires an enclosure for the electronic devices and a mechanism that would be worn on a human wrist. The medical smartwatch was designed to have electronic devices such as an electrocardiography (ECG) sensor, impulse and oximeter sensor, light emitting diode (LED) light, a battery, Bluetooth module, humidity and temperature sensors, flame sensor, vibrator, electromyography (EMG) sensor, Infrared (IR) LED sensor, transistor, and a Arduino board and many more. The focus was designing an enclosure that will interface between these electronic devices and the user. This paper shows the design that was considered for the enclosure, and the effect a casing has on the temperature and ECG sensors.*

Keywords: medical, monitoring, wearable technology

### INTRODUCTION

Smartwatches or wearable technology are multifunctional wrist-worn devices that can constantly monitor the user's physiological data. Smartwatches have applications like maps, music players and schedulers installed in them (Dehghani & Kim, 2019). There are different wearable technologies that are multifunctional, with some using technologies like biosensors and wireless data communication that allow the user to access and transmit their physiological data (Lu, Fu, Ma, Fang & Turner, 2016). Smartwatches can support health in everyday living since they monitor personal activity and obtain feedback based on these measures (Reeder & David, 2016).

Constant skin contact is one of the most important features that the enclosure must have to ensure that the sensors have enough contact with the relevant part of the patient's body. Constant skin contact in smartwatches allows easy recording of heart rate, heart rate variability, blood oxygen and galvanic skin response. Smartwatches that estimate heart rate are gaining popularity and are becoming

useful in medical tools in many ways. Although many smartwatches are not marketed for medical use, these devices have proven to be useful in patients with arrhythmias. There has been an increasing number of visits to medical rooms due to heart rate abnormalities detected by smartwatches (Koshy et al., 2017).

The use of wearable medical devices helps reduce hospital visits and admissions because of improperly managed personal health. Medical smartwatch users agreed that the wearable technology help them engage with their health. Companies worldwide are looking at the benefits that could come from the use of medical smartwatches by their employees. Medical smartwatches enable customers to have wearable pressure monitors and electrocardiography (ECG) sensors (Phaneuf, 2021).

There are mandatory quality management systems for medical devices to ensure that all medical devices adhere to all regulations before entering the markets. There are two regulations for medical device manufactures, these are ISO 13485 and 21 CFR 820. These regulations ensure that the medical devices are efficient and safe to use. ISO 13485 is focused on certificates based on the quality management system, management responsibility, resource management, product realisation and measurement, analysis, and improvement (Ramakrishna, Tian, Wang, Liao & Teo, 2015).

The research contributions presented in this paper are:

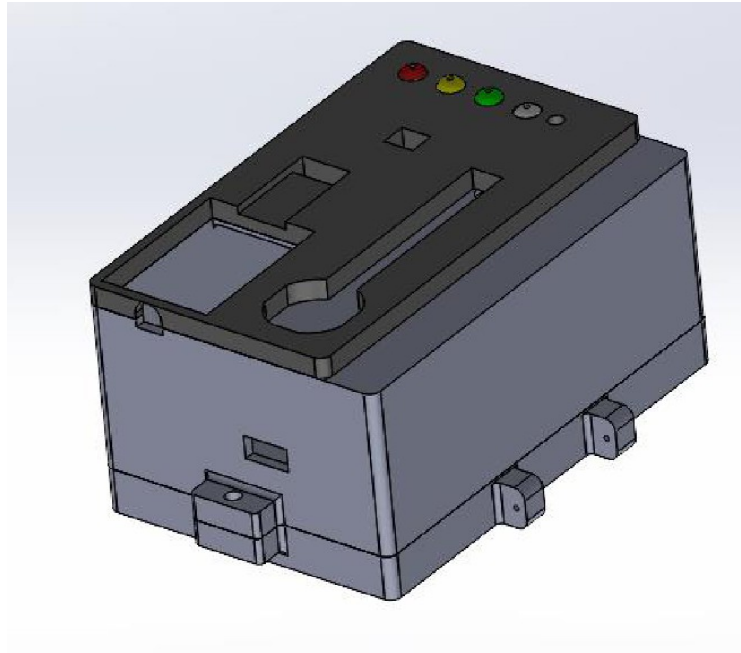
- The design of a wearable technology casing that will be in contact with a person's skin.
- Identifying if the casing has any effect in the reading comparison of the temperature and pulse rate sensors.

## **DESIGN AND METHODS**

The following design and methods were utilised for the developed wearable technology.

### **i. Materials**

The design as shown in Figure 1 was developed. It must be noted that this wearable device, also referred to as a smartwatch, does not display any information but integrates to the linked smartphone. The ECG was connected using wired electrodes that are attached to the forearm for sensing.



*Figure 1: The enclosure of the wearable technology where sensors were placed*

The advantages of this design concept are:

- The absence of a display screen reduces the number of electronic devices and therefore reduces the size and weight of the smartwatch.
- Increased accuracy of the sensor readings as they are in direct contact with the person's skin.

The disadvantage of this design is:

- The sensors are exposed to the environment, such as water. This means there is a need to identify a watertight system that will minimise any influence on the readings.

## ii. Methods

Tests were conducted for the different sensors to test the accuracy of the reading obtained by the sensor when they operate without the enclosure and inside the enclosure. These tests are performed to determine the deviations caused by the integration of the electronics with the enclosure.

The sensors that were tested were the LM35 temperature sensor and the Key studio AD8232 electrocardiography (ECG) sensor. With the temperature sensor, it is possible to measure the temperatures at the same time with two different sensors, one attached to the enclosure, and the other placed in contact with the person's skin. With the ECG comparison, it is possible to take readings with two different ECG sensors, one attached to the enclosure, while the other was placed in contact with the person's skin without the enclosure.

## RESULTS AND DISCUSSION

The temperature test results are shown in Figure 2. It is evident that the temperature sensor with the enclosure was consistent. The sensor that was not covered by the enclosure, shows an increase in temperature over time. The reason for the initial lower temperature was that the sensor exposed to the surrounding environment allows it to cool down by the moving air around it, and the temperature sensor had to stabilise with the transfer of heat from the person's body to the sensor.

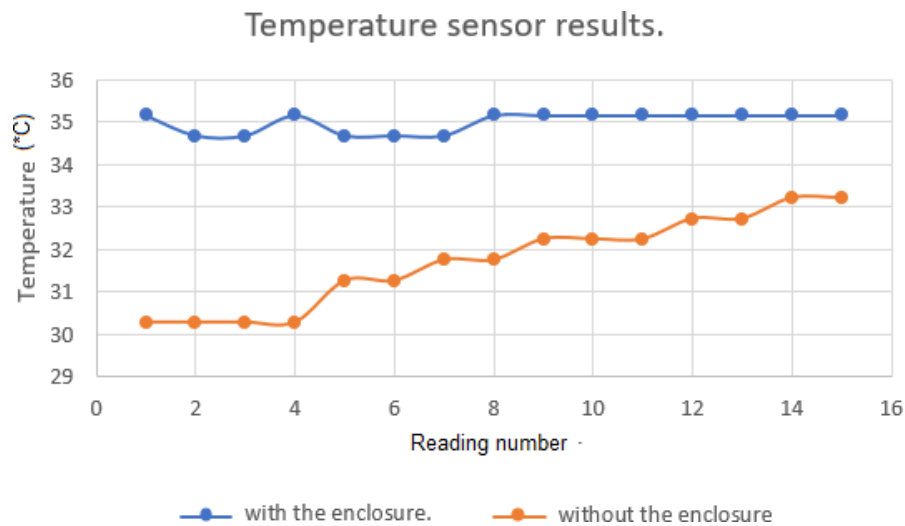


Figure 2: The comparison of the temperature sensors with and without the enclosure

The pulse rate sensor results are seen in Figure 3. The ECG sensor outside the enclosure was stable after two seconds, fluctuating with an increase or decrease of two bpm. The ECG sensor in the enclosure shows a decrease in the pulse rate over time, with a larger fluctuation of 17 bpm. These tests prove that the enclosure and electronics within the enclosure, has an impact on the readings. It is recommended that future work requires a means to prevent interference from other electronics with the ECG sensor.

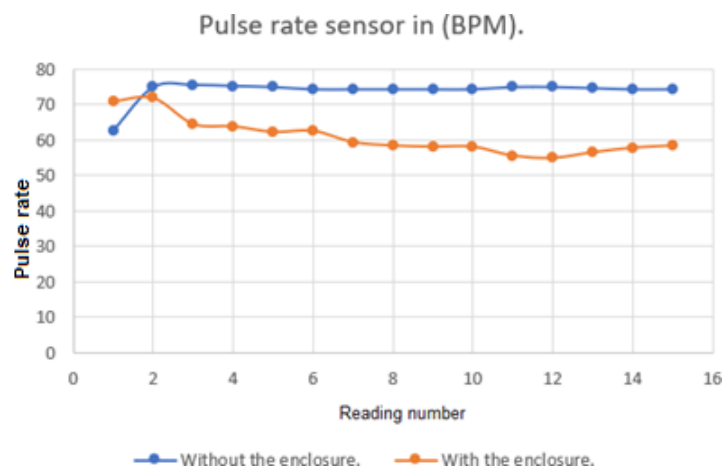


Figure 3: The comparison of the temperature sensors with and without the enclosure

## CONCLUSION

An enclosure was designed and tested to be used for a wearable device or a smartwatch technology. The effect that the enclosure has on the sensors were of interest, to identify if the sensors would need to be calibrated accordingly. The research contributions presented in this paper were achieved. The design of a wearable technology casing that will be in contact with a person's skin, has been developed. It was shown that the temperature sensor was able to obtain a stable reading when in contact with the enclosure, to prevent interference from the environment. Yet, with the pulse rate sensor, it was found that there was interference with the electronics inside the casing, and therefore an insulation from interference must be considered for future wearable devices.

There is scope for future work. It would be of interest to examine sensor readings and the calibration criteria required if the sensors were placed in a watertight casing.

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