Abstract — There are various non-invasive heart rate monitoring devices available for monitoring & diagnosis of the patient. It has been observed that the final values of the device are altered by the motion. This paper overcome the problems related with variations in the health parameters due to the motion of the object by developing a viable device to catch human critical physiological parameters like heart rate. The configuration of this heart rate checking device was focused around an automatic noise cancellation system utilizing 3-axis MEMS accelerometer to recover signals ruined by body development which is the principle source of motion artefacts.

Keywords — motion artifacts, 3 axis accelerometer and heart rate

I. INTRODUCTION

In modern times cardiovascular diseases are becoming common in people. They have become the main cause of patient’s death. So we need to make devices which can continuously diagnose and monitor the individual health parameters for the earlier detection of the diseases.

In recent times with the growth of telemedicine technology there has been different methods developed for better service quality in the health care systems. Various kinds of sensors have been developed to measure important health parameters.

PPG sensor is now one of the most widely used sensor to measure several health parameters like oxygen saturation, heart rate, heart rate variability and respiration rate. Physiological measurements from a single sensor allow wearable monitoring devices to be miniaturized for portability and field use.

The PPG sensor works on the principle of BEER LAMBERT’S LAW. This law states that when a light falls on a homogeneous substance , intensity of transmitted light decreases as the distance through the substance increases whereas BEER’S law states that when a light is transmitted through a clean substance with a dissolved solute , the intensity of transmitted light decreases as the concentration of the solute increases.
Pulse oximetry gauges blood vessel oxygenation by measuring the ingestion of light in tissue cots. By measuring the progressions in light ingestion permits estimation of heart rate and blood vessel oxygen immersion.

There are diverse wellsprings of ingestion in a tissue cot throughout the utilization beat oximetry.

Fig. 3. Variations in light attenuation by tissue, illustrating the PPG signal generation

Fig. 3. Illustrate the generations of the PPG signal by various constituents. The absorption of light by various constituents is divided into two components namely component A and component B. Component A shows the alternate part by due to arterial blood whereas component B constitutes constant part due to venous blood, bone, fat, etc. At the point when light is passed through tissue a portion of the light is retained by every constituent of the tissue structuring the DC part yet the main variable (AC) light retention is blood vessel blood. The transmitted light is detected by a photo-detector and is used to generate PPG signals.

Pulse oximeters are highly promising when utilized within unmoving circumstances. Pulse oximeters are formed for field applications to resistant the impacts of movement artefacts which are known to significantly debase the signal to-noise ratio (SNR) of PPG signs from which the physiological qualities are determined. Usage of a vigorous pulse oximeter for field applications obliges modern sophisticated noise algorithms to take out wrong readings and false cautions. Reduction of the motion artefacts from the PPG signals is the primary challenge in order to use the device in field applications or at home.

The main problem to remove motion artefact is that the frequency range of motion signal corrupting the PPG signal overlaps with the cardiac frequency so we cannot employ simple low pass filter to remove the noise.

As the noise introduced is unpredictable and unknown we cannot design fixed filters.

II. HARDWARE DESCRIPTION

In this the system comprises of the three main parts. First part consists of the PPG sensor and 3-axis accelerometer. The PPG sensor is made up of red led and photo-detector. The PPG sensor generates the PPG signal and the output of the 3 axis accelerometer serves as the reference signal for motion artefact. The output of both PPG sensor and 3-axis accelerometer are amplified and filtered before passing the signals to second part.

The second part consists of the ADC and the microcontroller. The analog signals from the PPG and the 3 axis accelerometer are first converted in the digital form for the processing of the signals by microcontroller. After ADC the data is processed by the automatic differential motion artefact cancellation technique. The technique is shown in the fig.4.

Fig. 4. Block Diagram of the System

The accelerometer signals are calculated at rest and in case of motion. The voltage signals generated by the accelerometer at rest are to be subtracted from the signals during motion to get the proper output voltage. The force movements would produce voltage signals accordingly. These analog voltage signals generated are converted in to proper digital signals by ADC. These signals serve as the reference signals for the motion artefacts.

The ADXL335 yield is ratio metric; with the change in supply voltage the output lines of the accelerometer also changes. When Vs=3.6 V, the output affectability is 360mv/g. When Vs=2v, the output affectability is 195mv/g. The zero bias output is likewise ratio metric so the zero g output is ostensibly equivalent to Vs/2 at all supply voltages.
The output is converted from all the 3-axis of the accelerometer in to proper voltage we use the formula is

\[ V_{axis} = \frac{ADC_{axis}}{256} \times V_{ref} \]

By using this formula accelerometer signals are converted in to proper voltage signals. These signals are then subtracted from the corrupted PPG signals to obtain the noise free PPG signals.

To measure the heart rate following formula is used. This formula gives the heart rate in real time. The formula is

\[ \text{Heart Rate} = \frac{60}{T} \]

Where \( T \) is the time between the two consecutive peaks of the PPG signal.

### III. Result

The results of heart rate examined on different subjects by developed prototyped system and without motion artefacts reduction device. Results of both values are compared and at last error is also calculated. Fig.5 shows the designed system.

The fig.6 shows the initialization of the heart rate monitoring system when the PPG sensor is contacted with human body.

Figure 5: Designed system

![Figure 5: Designed system](image)

Figure 6: Initialization of the System

![Figure 6: Initialization of the System](image)

The fig.6 shows the initialization of the heart rate monitoring system when the PPG sensor is contacted with human body.

The experimental testing of the system is done in the rest and in the motion. There was variation in the PPG signal. The AC components induced due to the variation in the arterial blood of the human body. The reference indicator is utilized as a sign that being created from the accelerometer. The reading was taken in static and unwinding mode, where there is no movement or physical activity throughout the examination. The fig.8 shows the PPG signal when there is no motion.

Figure 7: Testing of the Heart Rate Monitoring System

![Figure 7: Testing of the Heart Rate Monitoring System](image)

Figure 8: PPG signal when there is no motion

The corrupted PPG signal due to motion artefact is shown in the fig.9.

Figure 9: PPG signal with motion artefact

![Figure 9: PPG signal with motion artefact](image)
As in the figure 8 the corrupted PPG signal contains large number of peaks. These excessive peaks are due to motion artefact which leads to false calculation of Heart rate.

So in order to remove the noise both the corrupted PPG signal and the reference noise, that is, accelerometer signal are given to the microcontroller, where automatic noise cancellation differential algorithm is applied. The output of the automatic noise cancellation differential algorithm gives us the original PPG signal. The original PPG signal after the removal of noise is shown in fig.10.

Table 1

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age</th>
<th>M/F</th>
<th>Heart Rate Measurements</th>
<th>Percentage error</th>
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<td>Reference Pulse oximeter</td>
<td>Developed system</td>
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Table 1. shows the heart rate calculated by the reference pulse oximeter and also by the developed system at rest. Different subjects of different ages are taken to measure their heart rate for the testing of the developed system. Both males and female subjects are taken for testing. The percentage error is also calculated.

The comparison of both the reference pulse oximeter and the developed system is also shown with the help of graph in fig.11 and in fig.12.
This work leads to the lifesaving of human being, as it is used in such significant task, furthermore there are some amendments that can be consider in this work. As per development in the world, it can be implement in future on Android based operating system, so that the user can check the corresponding value real time and can also able to transmit those values to doctor via application designed and can get solutions from him. Moreover, the app can be linked up with various health related applications available on the Android based store so that the user get suggestions for maintain the constant heart rate and other related parameters.

Response time of the device can be reduced by taking new algorithm in account with improving in accuracy.

REFERENCES


Table 2: Testing of the Designed system in Motion

<table>
<thead>
<tr>
<th>Subject</th>
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<th>Heart Rate measurements</th>
<th>Error</th>
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Figure 12: Comparison of Pulse oximeter and Developed System in motion

The developed system is also tested in case of motion for the different subjects. Fig.12 shows the comparison graph between the reference pulse oximeter and the developed system.

IV. CONCLUSION & FUTURE WORK

The circuit is designed in the lab and is tested in rest and in different types of motions. The circuit is showing promising results in both rest and motion conditions. The output of the corrupted PPG and the accelerometer need to be synchronised before applying to the differential technique. The PPG signal should be shifted so that the unwanted signals should get subtracted from the corrupted signal and the desired signal is obtained.


