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Heart Rate Measurement System Based on Pulse Sensors with Pathophysiological Appearance

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Abstract

Measuring the number of pulses has been used in the medical world to determine stress, relaxation, physical fitness levels, and other medical conditions. Due to the importance of checking heart rate, it is necessary to have a portable and practical heart rate measuring device so that patients with heart disease will be easier to be monitored. The device is equipped with pulse sensor to measure the heart rate in real time and provide a beats per minute (BPM). The results of normal heart rate conditions, bradycardia, and tachycardia can be monitored using mobile device application based on the measured BPM. This can be seen as output voltage generated by the pulse sensor. This pulse sensor has an average percentage error of 1.77% and deviation of 2 that is relatively small compared to standardized devices. The device is connected to the mobile application by Bluetooth which the coverage is 11 up to 45 meters depends on the obstacles.

Keywords: Bluetooth;BPM; Heart Rate Measurement System, Pulse Sensors

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1. Introduction

There are four components of the main vital signs that health professionals must monitor regularly, namely blood pressure, pulse, respiratory rate, and body temperature. The heart is the most important organ in the human body, because the heart is the main organ in circulating blood throughout the body. Heart rate is the throbbing of the heart due to blood flow through the heart. According to the World Health Organization (WHO), a normal heart rate is from 60 to 100 beats per minute (BPM), with an average of 75 times per minute. At such speeds, the heart cycle lasts for 0.8 seconds, which are 0.5 second cystole and 0.3 second diastole. If the heart rate is less than 60 is usually called bradycardia and heart rate greater than 100 is usually called tachycardia [1]. Normal heart sounds have a frequency range of 20 Hz to 40 Hz, while abnormal heart sounds have a frequency range of up to 1000 Hz [2].

Electrocardiograph (ECG) is a standard medical device commonly used by medical teams to detect heart rhythms and rhythms. The ECG device cannot be used independently by the patient to detect the patient's pulse. In addition to the high cost of procuring an ECG, ECG equipment also requires special capabilities in its operation. Heart rate monitoring can be done using direct (direct) or indirect (indirect) techniques. Directly carried out by censoring the heart itself. Whereas indirectly by utilizing blood vessels, namely by conducting leads or sensors on the bloodstream [3].

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The Sample Registration System (SRS) survey in 2014 showed that Coronary Heart Disease (CHD) in Indonesia was the highest cause of death at all ages after stroke. The number reaches 12.9 %. Riskedas data in 2013 also shows the highest prevalence for cardiovascular disease in Indonesia is CHD, at 1.5 % .Therefore, it is needed a portable and practical heart rate device (easy to carry and easy to use), and makes it easy for paramedics to monitor the state of the heart [4].

Previous research has been conducted on vital signs measuring devices. The instrument only measured the beat per minute (BPM) and displayed the data on the LCD [5]. In another study, an instrument measured the heart rate using a pulse sensor [6][4]. In this research, an infra-red based instrument is designed to measure heart rate remotely using mobile phone. The result is further utilized as an indication of pathophysiological symptom.

2. Method

This study was conducted in several stages, namely hardware design, software design, testing tools, and analyzing results to draw conclusions.

2.1 Hardware design

Fig 1. shows a block diagram of a pulse sensor based heart rate measuring device. The design of the tool in this study consisted of several blocks of circuits arranged into a measuring instrument for the number of heartbeats.

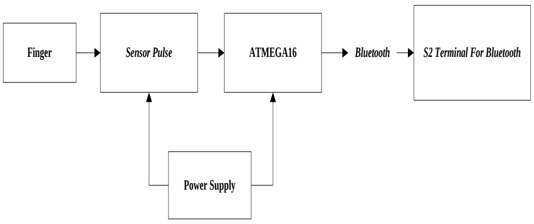

Fig 1. Block diagram of a pulse sensor based heart rate measuring device

Figure 3. shows a pulse sensor schematic circuits created in proteus software simulations. In this simulation the pulse sensor circuit produces a signal that can be measured with a digital oscilloscope. The output signal on this pulse sensor is an analog signal which subsequently is processed by the microcontroller .

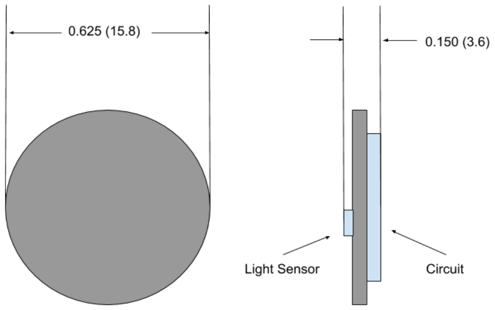

Fig 2. Physical dimension of pulse sensor

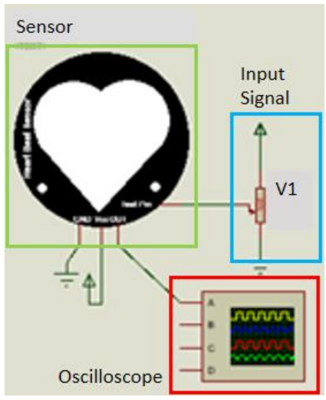

Fig 3. Pulse sensor schematic circuit

The minimum system required for implementing the ATMega16 integrated circuit (IC) consist of an oscillator circuit and a reset circuit (for power on reset). The minimum system power supply is 5 volts. The minimum system circuit can also be adjusted with various applications that will be used in accordance with hardware design [7].

Fig 4. shows a schematic of entire system which is integrated with a bluetooth module. The pulse sensor input is set by a potentiometer to simulate the heart beats. The testing is conducted on Proteus software. The result observed in digital osciloscope is shown in Fig. 5. The pulse sensor output is connected to the ADC0 pin of the microcontroller to retrieve the pulse data. A bluetooth HC-05 module is connected to the UART pin of the microcontroller to transmit the data to the smart phone [8].

In device implementation, pulse sensor detects blood-flow of the finger which reflects the infrared light coming from the sensor. The heart beats which are related to the blood concentration affect linearly the output of the sensor. Then obtained signal is subsequently amplified and filtered so that the signal level is readable by ADC pin. The input is processed as a heart rate input signal after 1 minute of measurement, the results of processing or enumeration are displayed in the application display [9].

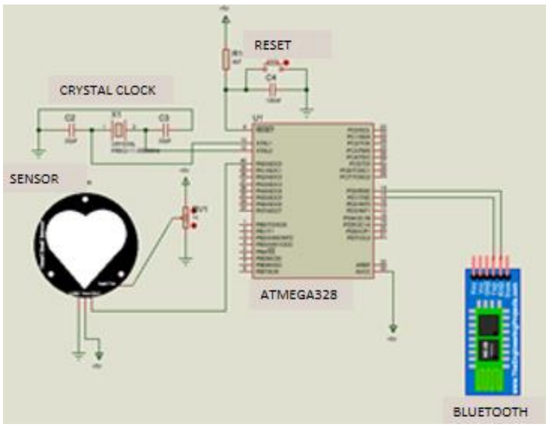

Fig 2. Schematic off all device with a Bluetooth modules

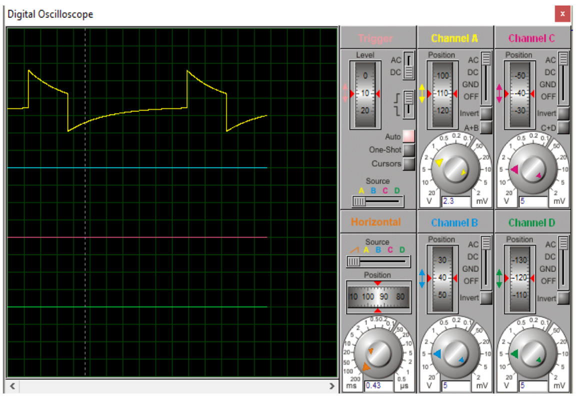

Fig 5. Pulse sensor testing with a digital oscilloscope

3. Results and Discussion

Pulse sensor testing with a digital multimeter is conducted to determine the voltage value generated by the pulse sensor. According to sensor data sheet, the output is a half of the supply voltage. Fig, 6 shows that our sensor is matched with the specification.

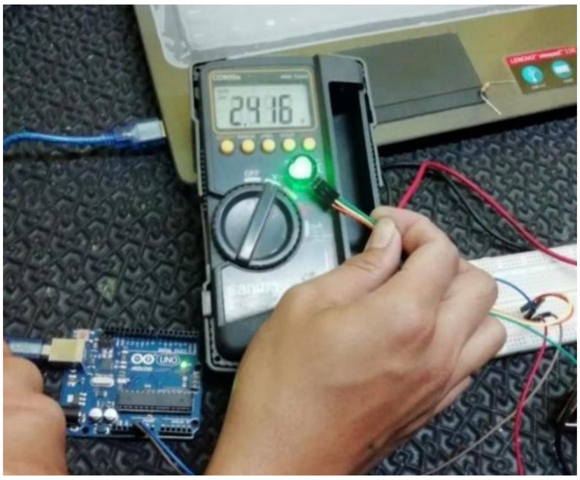

Fig 6. Pulse sensor measurement with heart rate detection

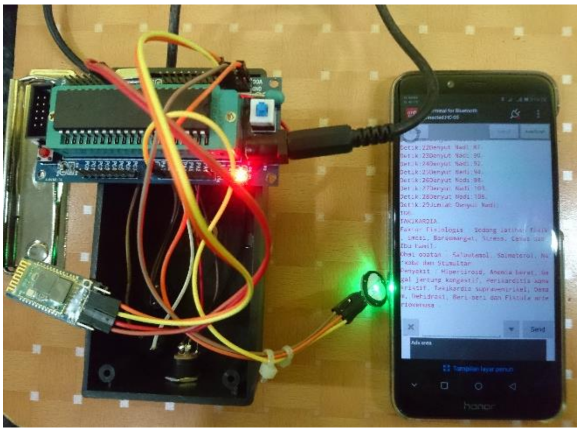

Fig 6. Heart rate measuring device

Figure 7 shows that the supply voltage does not only activate the pulse sensor, but also the bluetooth HC-05 module. It is indicated by LED light in both Bluetooth and sensor module. We also ensure that the HC-05 module is connected to mobile device.

The testing result shows that the bluetooth HC-05 is well connected and is able to transmit data from the microcontroller to the mobile device. The maximum distance between the microcontroller and mobile device is 11 meter and 45 meter with and without wall barrier, respectively

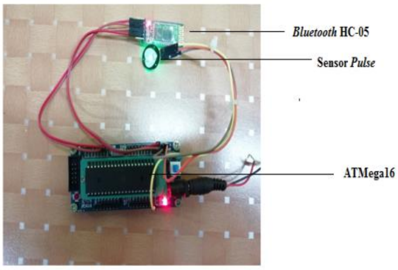

Fig 7. Testing process of Bluetooth module.

Heart rate measurement test

Direct testing of equipment is carried out on ten respondents voluntarily. The measurement result is displayed in mobile device as shown in Fig.8. Our system (TA) is compared to the standardized tool of pulse oximetry device (AP) to determine the level of error and deviation. The data is further analyzed to determine the pathological information. The result is shown in Table 1. Our system works properly with error and deviation below 4 % compared to the standardized tool. The difference between TA and AP measurement might come from the disturbance that occurs when determining the right point on the fingertips.

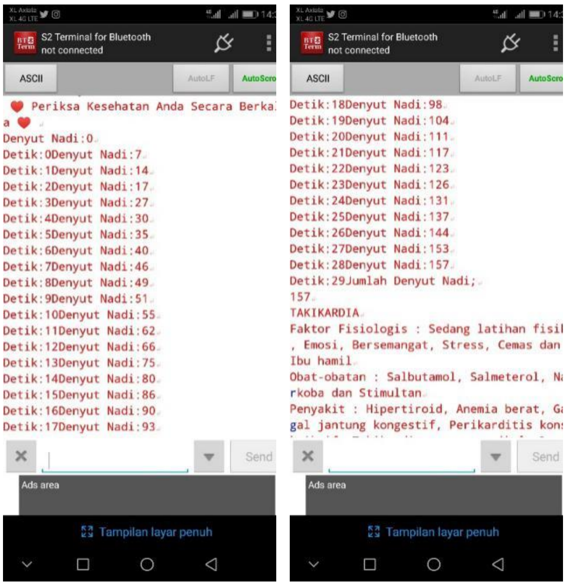

Fig 8. Display of measurement on mobile device.

Table 1. Testing result

No.	Test Equipment		Dev	*Error*	Info
	TA	AP			
1.	77	78	1	1,2 %	Norma
2.	78	81	3	3,7 %	Norma
3.	81	84	3	3,5 %	Norma
4.	88	90	2	2,2 %	Norma
5.	74	76	2	2,6 %	Norma
6.	105	103	2	-1,9 %	Tachycar
7.	53	55	2	3,6 %	Bradycar
8.	157	155	2	-1,2 %	Tachycar
9.	64	66	2	3,0 %	Bradycar
10.	68	69	1	1,0 %	Bradycar
	84,5	**85,7**	**2**	**1,77 %**	

4. Conclusion

In summary, we conclude that our system works properly compared to the standardized tool. The Bluetooth HC-05 module can connect the system up to 11 meter and 45 meter with and without wall barriers, respectively. From the heart beat measurement, our system is a able to display the possible pathological factor which should be confirm further by the medical expert.

Acknowledgment

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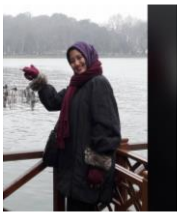

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