



Development of low cost heart rate device for contribution rural local medical in Nakhon Phanom province Thailand

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Abstract

The problem shortage of medical devices in rural Thailand, cause a budget to limit and constrain. Therefore a development the medical device with low cost as one solution. This paper proposes an improvement the heart rate device to applied in the rural local medical in Nakhon Phanom province. The hardware circuit consist the instrument amplifier, low pass filter, auto adjust zero and microcontroller processing, acquisition signal parameter of heart rate. First step the detection heart rate in the pulse signal and count the pulse in the one minute to get the beat per minute (BMP) detection pulse with a finger and measure the intensive light. The pulse signal to amplified with the instrument amplifier and send to the microcontroller. The count value of pulses per minute and show heart rate in BMP digital. Results show that compared with experimental commercial device and low cost device base on medical criterion, the average error results approximation 1.31%, it is confirm that the medical low cost device could work in the target areas.

Keywords: Heart rate detection, Low cost medical device, Finger sensor, Microcontroller

1. Introduction

The investigation of heart rate was an important because show and monitor the compression of heart to blood pump to nourish of the human body as a unit of measurement per minute. The rate of the heart rate of the people is changing. Based on the activities that in daily such as, walking, standing, sitting, sleeping, and effect on the state of stress. As well as the overall health of our people [1]. Traditionally studied about heart rate typically, during relaxes time a heart rate at 72 times per minute or about 60-80 times per minute, infants and young children have a heart rate 90-140 time per minute. For athletes are training for a long time and exercise regularly may have a heart rate of 30-50 time per minute [2-3].

In the general pulse signal are generate from physiological activity which have small voltage amplitudes ,therefore will to amplified signal before their processing and display can be accomplished. ECG signal are typically in the range of ± 2 mv and require a recording band width of 0.05 to 150 Hz [4]. That is very weak in amplitude, hence the amplification of about 1000 time are required for displaying and proper ECG signal. However the ECG signal to amplified with the amplification factor of 1000 at this stage noise will also get amplified along with the actual ECG signal. Hence signal amplification factor is kept low for front end amplifier. The instrument amplifier AD620 has been to apply in the bio-electronic and low cost which is low power are maximum current supply of 1.3 mA, power supply range

2.3V-18V ,signal accurate and also very important in selection to choose the equipment in for creation medical device.

Recently literature researchers have techniques applied of Photoplethysmograph (PPG) for an implements and presented concept development and validation. Heart function in patients with cardiovascular disease and the development of data recorded data. Electrocardiogram (ECG) signal analysis, notification system investigation of the heart. However, no further results on this research are disclosed [5-7]. Moreover have many methods to measure heart rates such as the Phonocardiogram (PCG), ECG, blood pressure wave form and pulse meters [8-9], but these methods are clinical and expensive. There are other cost-effective methods that are implemented with sensors as proposed in and but they are susceptible to noise and movement of subject and artery [10-11].The goal of work to create hart rate device with cost a less than 1,000 THB, but its could work in rural medical base on medical criterion which the budget shortage.

This paper purpose a design and development a heart rate device for apply in rural medical with low cost and presented provides method, compare accurate reading of the heart rate with commercial device .In this paper is organized as follows: Section 2 presents the methodology and material for implement hardware used in our experiments and heart rate principle is described in this section, followed by the experiments and result in Section 3. Finally, the paper ends with the discussions and conclusions.

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2. Materials and methods

2.1 Principle of heart rate

The heart of human composed of muscle tissue to action in body and support a circulatory system pump blood to the body of human. It also controls the flow of important nutrients and oxygen. For the investigation heart rate can be measured by the active of the pulse.

Table 1 Average of heart rate criteria [6]

Age	Average	good	Excellent
New born	140	120-180	140
7-13 year	85-90	85-90	85-90
14-17 year	80-85	85-90	85-90
18-25 year	70-73	62-65	56-61
26-35 year	71-74	62-65	55-61
36-45 year	71-75	63-66	57-62
46-55 year	72-76	64-67	58-63
56-65 year	72-75	62-67	57-61
> 65 year	70-73	62-65	56-61

For Table 1 the explain and describe of average of heart beat rate and show that know about normally , heart rate should stay between 60-80 beat per minute. In addition, the table also has the advantage of using a check of data analysis for medical health. To know the situation of human health and information for physicians for diagnosis in the medical. In addition, we used the data in table to compared with measure the heart rate device.

2.1.1 Principle of heart beat sensor

The principle of heart rate monitor used measurement of the arterial oxygen saturation. Lighting absorb a different of hemoglobin binding to oxygen and reduced a hemoglobin. HbO2 absorb an infrared light, have wavelength range an estimation 850-1000 nm. Also the heart squeezes and relaxes. It happened pulse transmitted to the blood which can detect signals using LED infrared.

The determine instantaneous of heart rate via measuring the time interval between successive beats, often to the nearest millisecond, and converting that to heart rate by taking its reciprocal. Since technical measure heart rate in beats per minute, the interval between beats is often converted to heart rate using the first equation [7].

$$\text{Heart rate in beats per minute} = \frac{60,000}{\text{Beat, interval, milli second}} \quad (1)$$

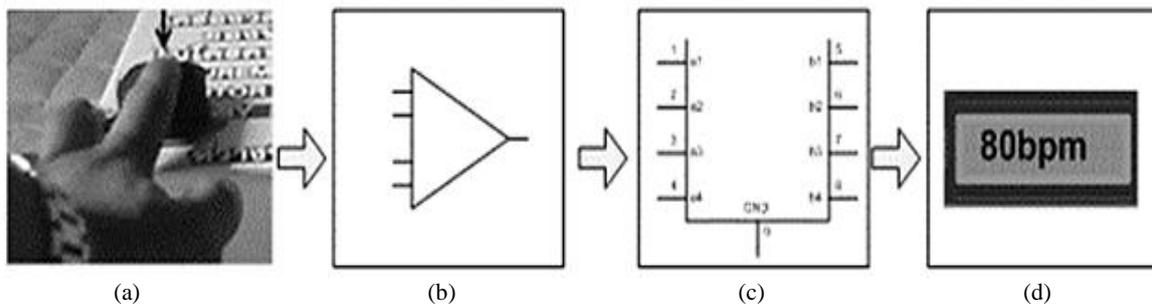


Figure 1 Overview diagram system of heart rate system (a) Finger IR LED sensor (b) Filter and amplifier circuit (c) Microcontroller (d) Display heart rate

2.1.2 Concept for design circuit

This study using a microcontroller based and describes a technique of measuring the heart rate through a fingertip using an arduino microcontroller. While the heart is beating, it is actually pumping blood throughout the body, and that makes the blood volume inside the finger artery to change too. This fluctuation of blood can be detected through an optical sensing mechanism placed around the fingertip. The signal can be amplified further for the microcontroller to count the rate of fluctuation, which is actually the heart rate [1].

Figure 1 shows the block diagram of heart rate system consists, first block describe an infrared light emitting diode and a photo diode and placed fingertip, Second block is filter and gain amplifier circuit, this little alteration in the amplitude of the reflected light can be converted into a pulse, Third is microcontroller for calculation and processing, fourth block is heart rate display monitoring in beat per minute.

2.1.3 Methodology for design circuit

The aim for design circuit of heart rate device consists two part , instrument amplifier ,active low pass filter have the cut off frequency about 2.5 Hz and the maximum for measurable to support investigation heart rate to 150 bpm, the concept of design used equation (2-5)

$$V_{out} = (1 + \frac{2}{a}) \times (E_1 - E_2) \quad (2)$$

$$V_{out} = \frac{1 / j\omega C}{R + 1 / j\omega C} \times E_i \quad (3)$$

ω is angular frequency, j is reactance of capacitor, V_{out} is output of low pass filter, E_i is voltage input, A_{CL} is Close loop gain

$$A_{CL} = \frac{V_o}{E_i} = \frac{1}{1 + j\omega RC} \quad (4)$$

The circuit design by equation was show that Figure 2, 3

3. Experiment and results

The heart beat rate device has been designed and improvement in this paper, as shown in Figure 4 , from testing of different three sample, age 20-39 group and measured four testing per day, recordings and compare with a criterion of heat beat rate.

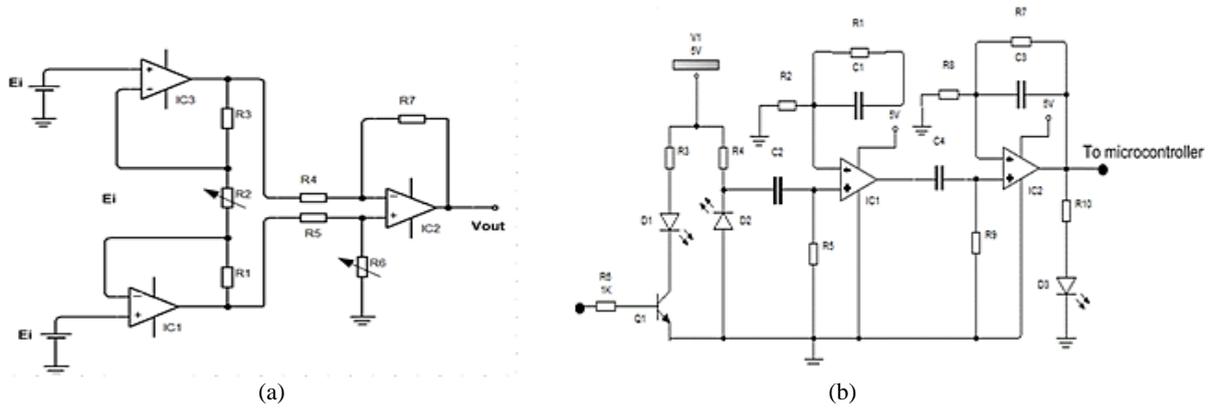


Figure 2 Circuit (a) instrumentation amplifier (b) low pass filter

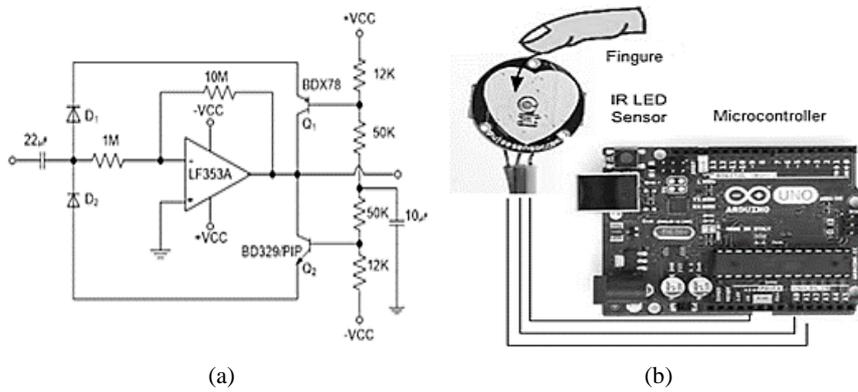


Figure 3 Circuit (a) auto adjust zero circuit (b) Arduino microcontroller

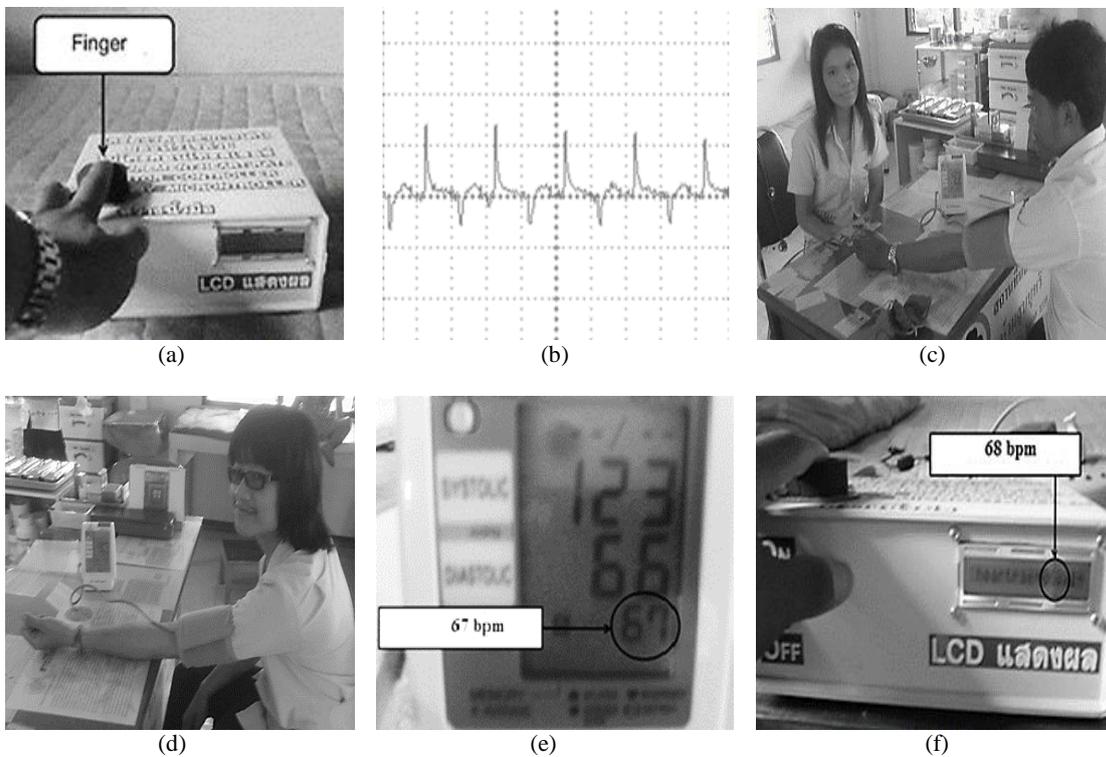


Figure 4 (a) Heart rate device, finger place (b) Signal of heart rate (c) Testing in rural local medical (d), (e) Testing with commercial heart rate device (f) Testing with innovation device

Table 2 Experiment results of heart rate device

Person 1	Commercial bpm	Innovation bpm	Error(%)
Test 1 th	67	68	1.47
Test 2 th	76	75	1.33
Test 3 th	76	76	0
Test 4 th	76	76	0
Person 2	Commercial bpm	Innovation bpm	Error
Test 1 th	89	88	1.13
Test 2 th	78	80	2.5
Test 3 th	75	76	1.31
Test 4 th	75	74	1.35
Person 3	Commercial bpm	Innovation bpm	Error
Test 1 th	73	72	1.38
Test 2 th	83	84	1.19
Test 3 th	83	82	1.21
Test 4 th	83	82	1.21
Average error(%)			1.31%

4. Conclusions and discussion

This paper present an improvement of an innovation heart rate low cost device monitoring, which is useful for rural local medical at a budget limit. The literature review concept and the important development for contribution target. Experimental device in laboratory of NPU. After that application device to the rural medical in Nakhon Phanom province Thailand, From Table 2 the results its is confirmed that the device could be operate to agreement, we test and compared with a commercial heart rate device and medical criterion, results show that the average error approximate 1.31%, which to acceptance error calibration criteria of heart rate in medical, $\pm 2\%$ [9], Moreover the results measurement of peoples have a follow with criterion of normal heart rate age. [6-8], however the quality of electronic device cause the influence for accuracy and efficiency. In the future, we will extend heart beat rate device and noise signal reduction, sensitivity problems and development such as, monitoring signal and analysis real time signal.

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6. References

- [1] Landaeta RG, Casas O, Areny RP. Heart rate detection from plantar bioimpedance measurements. 28th IEEE EMBS Annual International Conference; 2006 Aug 30-Sept 3; New York City, USA. New Jersey: IEEE; 2006. p. 5113-5116.
- [2] Shim H, Lee JH, Hwang SO, Yoon HR, Yoon YR. Development of heart rate monitoring for mobile telemedicine using smartphone. International Federation for Medical and Biological Engineering 2008;23:1116-1119.
- [3] DeBoer RW, Karemaker JM, Strackee J. Comparing Spectra of a Series of Point Events Particularly for Heart Rate Variability Data. IEEE Transactions on Biomedical Engineering 1984;31(4):384-387.
- [4] David P, Michael N. Design and Development of Medical Electronic Instrument: A Practical Perspective of the Design, Construction, and Test of Medical Device. USA: John Wiley & Sons publications; 2005.
- [5] Steenis HG, Martens WLJ, Tulen JHM. Time-frequency parameters of heart-rate variability. IEEE Engineering in Medicine and Biology Magazine 2002;21(4):46-58.
- [6] Science Museum of Minnesota [Internet]. Range of Heart Rates per Minute and Average Heart Rate for Various Ages. 2000 [cited 2016 April 1]. Available from : <http://www.smm.org/heart/lessons/lesson1.htm>
- [7] Neuman MR. Vital Signs: Heart Rate. IEEE Pulse 2010;1(3):51-55.
- [8] Jubadi WM, Aisyah Mohd Sahak SF. Heartbeat monitoring alert via SMS. Industrial Electronics & Applications 2009;2:1-5.
- [9] Department of medical engineering Thailand. Calibration tool of medical manual ISO 15189. Lecture document [Internet]. 2013 [cited 2016 April 1]. Available from: <http://medi.moph.go.th>
- [10] Miah MAR, Basak S, Huda MR, Roy A. Low cost computer based heart rate monitoring system using fingertip and microphone port. 2013 International Conference on Informatics, Electronics & Vision (ICIEV), 2013 May 17-18; Dhaka, Bangladesh. New Jersey: IEEE; 2013. p. 1-4.
- [11] Cabasson A, Meste O, Vesin JM. Estimation and Modeling of QT-Interval Adaptation to Heart Rate Changes. IEEE Transactions on Biomedical Engineering 2012;59(4):956-965.