

Fabrication of prototype for measuring the exhaled breath temperature (EBT) to support detection of asthma

Harnawan A.A.^{1,*}, Mariati, Fahrudin A., Assegaf A.²

¹ Physics Study Program, Universitas Lambung Mangkurat, Achmad
Yani Street Km. 35,8, Banjarbaru South Kalimantan, Indonesia

² Regional General Hospital Ulin, Jl. Ahmad Yani Km. 1, Banjarmasin
South Kalimantan, Indonesia

*corresponding author : adeagungharnawan@unlam.ac.id

Abstract. Recently, EBT has been proven as the marker of airways inflammation like asthma and proposed as the non-invasive tool. Although EBT device has already been made but this device is rarely used for patients in Indonesia. The aim of this study is to develop a prototype which accurately measures EBT and is comfortably used by patients including children. This prototype was made using SHT11 as a sensor of EBT which is integrated on a thermal flask 0.5L. This flask filled up patient breath and the temperature of air breath was measured. The EBT of twelve healthy samples and seven samples with asthma was examined using this prototype, the measurement was done within three minutes for all of them. The test results of EBT on healthy samples obtained the median is 33.9°C within of 33.0°C - 34.7°C and EBT on asthma samples obtained median is 35.0°C within the range 34.9°C - 36.0°C.

1. Introduction

Health is one of the most important parts of life. The level of a person's health can be determined from several aspects, one of which is on the performance of a respirator. Asthma is a chronic disease which attacks the respiratory tract bronchial on our lungs, where there is inflammation bronchial cavity wall resulting in constriction of the airways that ultimately leads a person experience shortness of breath. Paredi et al, in their study found that patients with asthma had a rise in EBT that were faster than normal people[1]. Garcia et al, in their research also found the same thing regarding the relationship between EBT and asthma. The research found that healthy people EBT was $33.2 \pm 0.2^{\circ}\text{C}$ compared to patients with uncontrolled asthma that was $33.7 \pm 0.8^{\circ}\text{C}$ and patients with uncontrolled asthma that was $34.9 \pm 0.8^{\circ}\text{C}$ [2]. Popov et al shows that EBT can distinguish both samples with and without asthma. In their research, the obtained EBT asthmatics are in the range from 34.12 to 36.09 and from 32.29 to 35.84 °C for healthy people [3],[4],[5].

To fulfill the purposes of measurement of EBT, it needs to be made an instrument that is capable of measuring EBT precise and easy to use. This article discusses the prototype of the measuring instrument EBT using SHT11 sensor-based microcontroller ATmega16 as an instrument for supporting the treatment of asthma.



2. Materials and methods

Steps to prepare the prototype for measuring EBT to support detection of asthma can be shown in Figure 1. All steps of fabrication of the system were done in the Laboratory Instrumentation of Physics on Faculty of Mathematics and Natural Sciences, Universitas Lambung Mangkurat. Then, the step testing system to support asthma detection was done in Regional General Hospital Ulinon Banjarmasin, South Kalimantan.

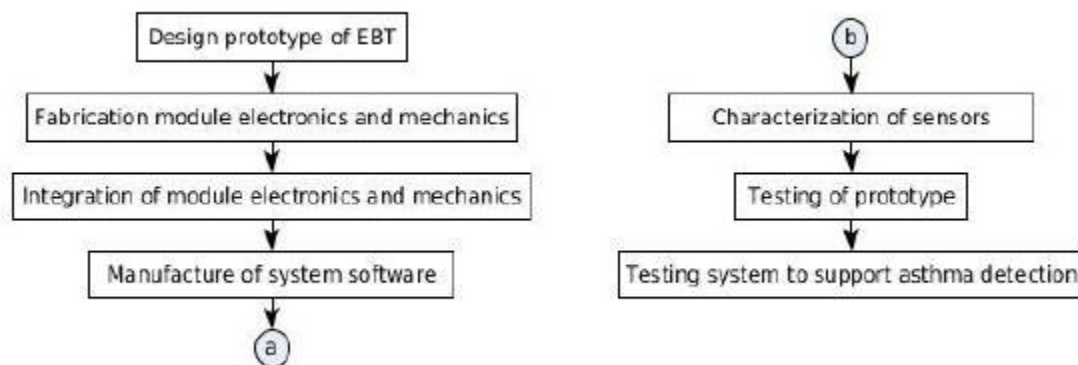


Figure 1 The steps to prepare the prototype..

2.1. Preparation tools and materials

Tools and materials used were electronics equipment, multimeter, personal computer, power supply, microcontroller module minimum system ATmega16 [6], RTC module, the SHT11 sensor with i2c interface [7], thermal flask, RS232 module, LCD 16x2 module, BASCOM, Personal Computer and several of cables.

2.2. Design prototype of EBT

A design of the system can be shown in Figure 2. The figure shows that the EBT is collected on the thermal flask then the EBT is measured with the SHT11 sensor and the data of EBT are displayed by LCD and saved by a personal computer.

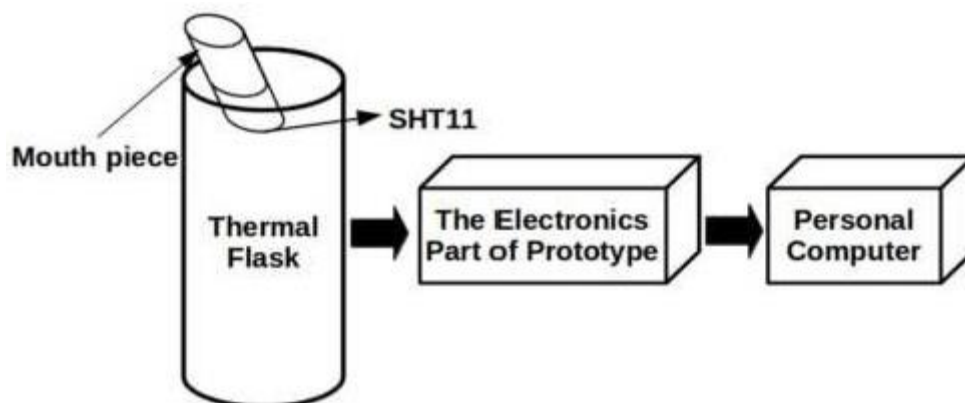


Figure 2 Design the system of prototype.

2.3. Fabrication module electronics and mechanics

The electronics part of prototype consists of sensor SHT11 placed in the thermal flask, module RTC (Real Time Clock), module LCD 2x16 and power supply. The power supply and RTC use the circuit that with microcontroller ATmega16 module. The interface of LCD 2x16 module with microcontroller module using configuration 4 bit. All the modules electronics are assembled and laid

on the box. Prototype electronic parts have the following specifications power supply with the output voltage of 5V, 12V and 12V. Power supply 5 V is required to turn SHT11 and minimum system. Minimum system ATmega16 uses 11.059200 MHz crystal.

The form of mechanics module is just the modification of thermal flask used to keep warm the liquid in it. It is equipped with the mouthpiece to blow the air from breathing results.

2.4. Integration of electronics and mechanics module

The integration between the two modules uses a cable that connects the sensor module SHT11 with ATmega16 microcontroller i2c input. The connection of data from the electronics part of a prototype to a personal computer use the RS232, type of digital communication. It was selected to prevent lost data on the cable connected to them because of the length of a cable. The prototype has integrated shown in Figure 3.



Figure 3 The prototype for measure EBT

2.5. Manufacture of system software

The algorithm embedded with Bascom to the microcontroller ATmega16 is shown in Figure 4. Microcontroller reads time from RTC module, then reads the EBT from sensor SHT11, then displays the value of sensors that reads the temperature of air in the thermal flask at LCD 2x16 module, then sends it to a personal computer.

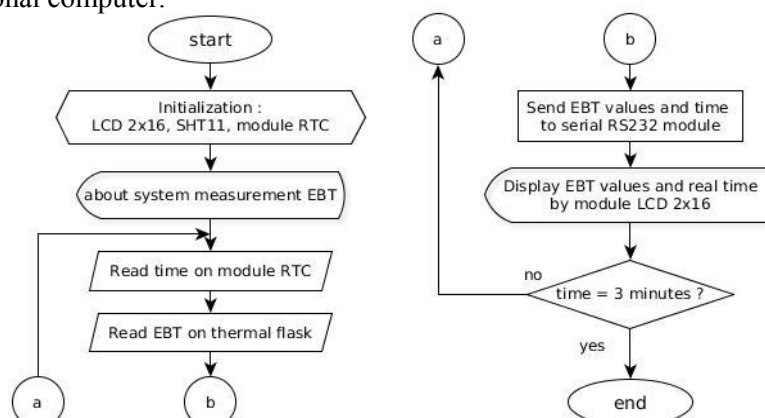


Figure 4 Flowchart embedded to microcontroller ATmega16.

2.6. Characterization of sensor SHT11

The characterization of SHT11 sensor aims to look at the performance of the sensor compared with a standard digital thermometer generating a correction factor from the prototype to the exhaled breath temperature measured.

Characterization is done by placing SHT11 and the thermometer in the same position in the thermal flask. The hot air is passed through a small tube into a thermal flask. Measurements were performed within a temperature range of 20 - 60°C with a temperature recording every increase of 0.1°C. The result in Figure 5 (a) shows the differences of SHT11 and thermometer readings and calculation. It is obtained that the temperature correction value was 3.5°C. based on the average of the difference between the temperature value by digital thermometer with a temperature value measured by the prototype. This correction added values of SHT11 and the result has been shown in Figure 5 (b).

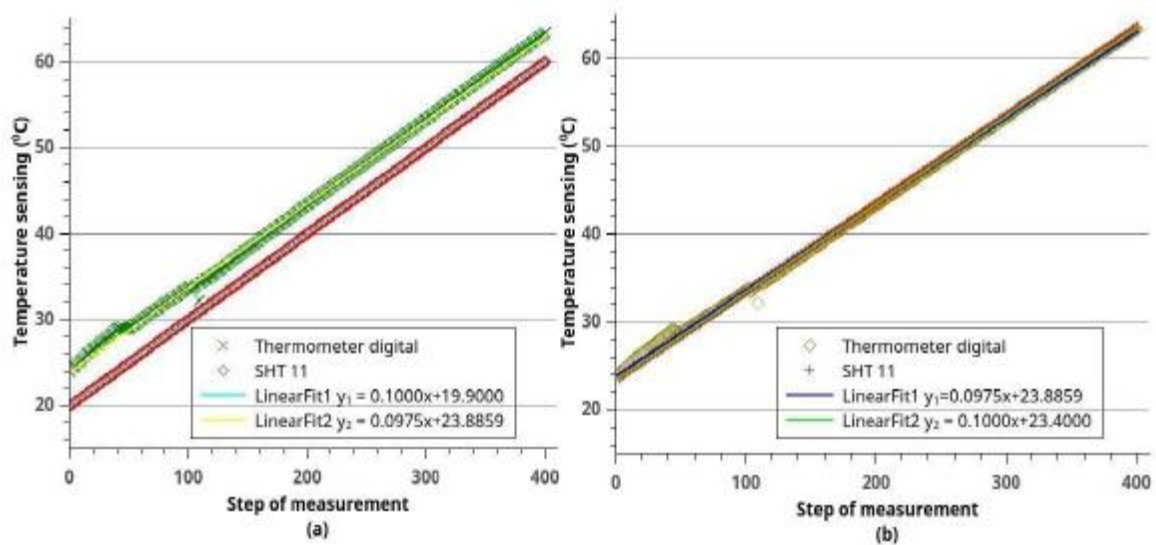


Figure 5 Characterization SHT11

On the results of correction as shown in Figure 5 (b) it was performed the paired t-test to determine whether the presence or absence of the difference in temperature readings by prototypes and digital thermometer. Based on the calculation, t_{value} was -2.02 than from the $t_{\text{distribution table}}$ for $df = 400$ t for 99% confidence interval of 2.5882, the value of $t < t_{\text{distribution table}}$ so H_0 is accepted. It means that there is no difference between a prototype and a digital thermometer.

2.7. Test of prototype

Tests were performed on 10 samples with repetition of data collection three times to determine the repeatability of measurement. The test results are shown in Table 1.

Table 1 The performance test of prototype to measure EBT

No	Samples	EBT ₁ (°C)	EBT ₂ (°C)	EBT ₃ (°C)	Average EBT (°C)	δ deviation
1	A	29.4	28.8	29.5	29.23	± 0.379
2	B	33.2	33.7	33.4	33.43	± 0.252
3	C	32.5	34.5	34.6	33.80	± 1.185
4	D	33.6	31.7	32.3	32.53	± 0.971
5	E	30.8	33.3	33.2	32.43	± 1.415
6	F	33.5	34.8	34.0	34.10	± 0.656

7	G	35.0	34.8	35.1	34.96	± 0.153
8	H	34.5	35.3	34.4	34.73	± 0.493
9	I	34.0	33.8	33.8	33.86	± 0.115
10	J	30.3	29.7	28.6	29.53	± 0.862

3. Data analysis

The next test of a prototype was conducted on 12 healthy samples and samples of 7 people with asthma. The highest temperature measured was taken as the measured value of EBT. The test results in healthy samples are shown in Table 2 and the results of tests on healthy samples are shown in Table 3.

Table 2. The result of EBT on health samples

No	Samples	EBT (°C)
1	A	34.5
2	B	33.3
3	C	34.7
4	D	33.0
5	E	33.9
6	F	34.7
7	G	33.5
8	H	34.1
9	I	34.0
10	J	31.1
11	K	30.3
12	L	34.3

Table 3. The result of EBT on asthma samples

No	Samples	EBT (°C)
1	M	34.9
2	N	34.9
3	O	36.3
4	P	35.4
5	Q	35.0
6	R	36.0
7	S	35.5

The value of EBT comparison charts of one sample of healthy and asthmatic is shown in Figure 6, starting at the second to 0-180s.

4. Result and Discussion

Table 1 shows that the performance measurement repeatability deviation of EBT was in the range 0.115-1.415, meaning the prototype can measure EBT correctly on samples.

Table 2 and table 3 shows that results of prototype testing on samples of healthy EBT values obtained a range from 30.3°C to 34.7°C and the sample asthmatics EBT values obtained a range from 34.9°C to 36.3°C.

Figure 6 shows a graph EBT difference between normal samples and samples with asthma. EBT for the sample chart with asthma is increasing faster than the normal sample from 0 to 180 seconds. EBT value at 180 seconds is considered a sample value EBT that was recorded.

A thermal flask in this research was used without the feature to clear the air after use, so they need a few minutes to equalize the initial conditions for the next EBT measurement.

The performance of the prototype needs to be improved to enhance EBT measurement and store data without using a personal computer, so that the necessary storage modules on the prototype so that data

can be read by a computer for further analysis. Then it should also be used for the LCD graphic to display data EBT measured directly on the prototype.

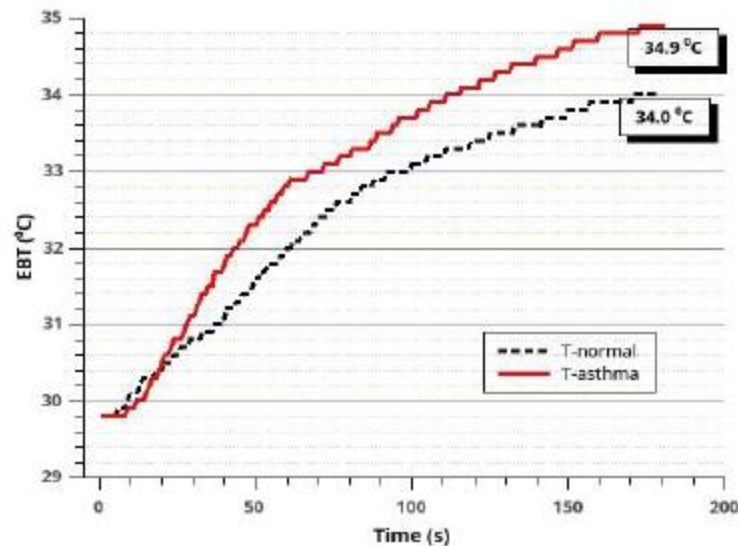


Figure 6 The difference graphics between EBT asthma and normal

5. Conclusion

Based on the results and discussion we concluded that the prototype can measure samples EBT in healthy and asthmatic. Results of prototype testing on samples of healthy EBT values obtained ranges from 30.3 to 34.7°C and the sample asthmatics EBT values obtained ranges from 34.9 to 36.3°C.

6. Acknowledgements

Researchers thank to the head of Instrumentation Laboratory of Physics Faculty of Mathematics and Natural Sciences University Mangkurat as well as all parties involved in this research.

References

- [1] Paredi, Sergei A Kharitonov, and Peter J Barnes 2002 Faster rise of exhaled breath temperature in asthma. *American Journal of Respiratory and Critical care Medicine*. **165** : 181 - 184
- [2] Garcia,M, M Bergna, E Uribe, A Yahez, and JB Soriano. 2013. *Increased exhaled breath temperature in subjects with uncontrolled asthma* Int J Tuberc Lung Dis 17(7) : 969 – 972
- [3] Popov, T A , Dunev S, Kralimarkova T Z, Kraeva S and DuBuske L M. 2007. *Evaluation of a simple, potentially individual device for exhaled breath temperature measurement*. Respir Med. 101 : 2044 – 2050
- [4] Popov, T A T Z Kralimarkova, C T Tzachev, S S Dunev, V D Dimitrov, and J Gill 2010. Development of an individual device for exhaled breath temperature measurement. *IEEE Sensors Journal*. **10** :110 – 113
- [5] Popov, T A, T Z Kralimarvo and T D Dimitrov 2012. Measurement of exhaled breath temperature in science and clinical practice. *Breathe*, **Vol 8** no 3, March 2012
- [6] Atmel 2010 8-bit Microcontroller with 16K Bytes in System Programmable Flash, ATMega 16. San Jose: Atmel Corporation.
- [7] Sensirion 2011 Datasheet SHT1x (SHT10, SHT11, SHT15) Humidity and Temperature sensor IC Switzerland : Sensirion AG