A Microcontroller-Based Sonometer

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Abstract. It has been designed and made a sonometer device that uses a microcontroller and LM567 frequency sensor module. The sound from the sonometer strings is detected by the module sensor. If the module sensor detects that the string sound frequency is the same as the tuning fork frequency, the microcontroller will display the word "Sesuai" on the monitor screen (LCD) which means the string frequency is equal to the tuning fork frequency. Conversely, if the frequency of the strings sound is not the same as the frequency of the tuning fork, the microcontroller will display the word "T Sesuai" which means the frequency of the strings is not the same as the tuning fork frequency. Compared to the conventional sonometer, this sonometer (the modified sonometer) produces more accurate frequency values. In this study, the maximum relative error of the modified sonometer is 0.30% while the maximum relative error of conventional sonometer is 10.86%.

1. Introduction

The Sonometer Experiment is an experiment that aims to prove that if the string tension is fixed and the length of the string is adjusted until resonance occurs, the tuning fork frequency will be the same as the basic frequency of the string. In this experiment, the tuning fork as a reference frequency will make the strings resonate when the string length is appropriate. The resonance of the strings is marked by the fall of small paper folds on the strings. The length of the strings during a resonance is then measured and the results entered in the equation to determine the resonance frequency. However, determining the occurrence of maximum resonance is rather difficult. This is because falling folds of paper can occur even though maximum resonance has not occurred. As a result, the resonance frequency obtained is not accurate. Therefore we need a tool that can determine the resonance frequency in a more accurate sonometer experiment.

The use of microcontrollers combined with sensors is widely used to control, facilitate data retrieval, get more accurate data and so on [1-5]. A microcontroller is an electronic device that can be programmed and has input and output. Input from the microcontroller can be connected to various electronic devices including sensors. The sensor detects the desired magnitude then is connected to the microcontroller input. The microcontroller processes the sensor detection results according to the program that has been uploaded to the microcontroller. The results of the microcontroller processing are then released through the output. The output of the microcontroller can be connected to a variety of electronic devices such as monitors, printers, and others.

Based on the above, a sonometer will be designed and manufactured using a microcontroller and sensor to get more accurate results. For sonometer experiments, we need a sensor that can detect the
frequency produced by the tuning fork. One of a sensor system that is widely used to detect frequencies is the LM567 frequency sensor module [6-8]. The advantages of this sensor system detect only one specified frequency value, the frequency can be set from 0.01 Hz to 500 Hz and so on. Because this sensor system only detects one desired frequency, this sensor is very suitable to be applied to the sonometer experiment.

2. Materials and Methods
The main materials used in this study are a set of sonometer, microcontroller, LM567 frequency sensor module, and liquid crystal display. The microcontroller used processing data from the LM567 frequency module and display the result on LCD.

Determination of the frequency is done by 2 methods. The first method is the resonance method where the frequency is calculated using the length of the strings measured when there is a resonance (small pieces of paper fall). The second method is the frequency calculated using the length of the strings measured when the sensor and microcontroller show the same string frequency with the tuning fork frequency. The two results of the method will be compared with the frequency of the tuning fork to determine which method is more accurate.

3. Results and Discussions
Figure 1 shows the design of the sonometer that has been integrated with the sensor module and the microcontroller. The sensor module is placed on the sonometer as shown in figure 1 to make it easier to detect frequencies of the strings. When the strings are sounded, the sensor module will give a signal to the microcontroller. The signal received by the microcontroller will be processed and the results will be displayed on the LCD display.

Figure 2 is a circuit diagram of the electronic system of a modified sonometer. The power supply will power all the components. The output of the LM567 frequency sensor module becomes an input for the microcontroller. The microcontroller processes the input and displays the result through the LCD.

Figure 3 shows the modified sonometer. The LM567 sensor module is placed in the middle of the sonometer and separated from the microcontroller and LCD. In the experiment, first, the frequency to be detected by the sensor module is adjusted to the same frequency as the tuning fork. This is done by means of vibrating the tuning fork and the potentiometer on the sensor module is adjusted until the frequency indicator lights up. If the frequency indicator lights up, the frequency to be detected by the sensor module is the same as the tuning fork frequency. When the frequency is the same as the tuning fork frequency, the output of the sensor module will be of high value (1) and be an input signal for the microcontroller to be processed and displayed on the LCD display. Furthermore, the strings are sounded,
then the movable bridges B and C are spaced so that the display says "in accordance", meaning the string frequency is equal to the tuning fork frequency. The movable bridges distance of B and C is then measured and entered in the equation to get the calculated frequency. Table 1 is a table of the results of frequency calculations obtained by means of resonance (conventional) and by using a sensor module combined with a microcontroller (modified).

![Diagram of electronic system of the modified sonometer](image)

**Figure 2.** Circuit diagram of electronic system of the modified sonometer

![Modified sonometer system](image)

**Figure 3.** Modified sonometer system
The frequency data in table 1 is an average value of 5 frequency values for each string tension value. Standard deviation (STDEV) data were also obtained from 5 trials. The relative error data is obtained by means of the average frequency value minus the tuning fork frequency value then divided by the tuning fork frequency value and multiplied by 100. The tuning fork used in this research has a frequency of 426 Hz.

**Tabel 1.** Comparison of modified and conventional frequency data

| Tension (N) | Frequency (Hz) | STDEV | Error (%) |
|------------|----------------|-------|-----------|
|            | Modified       | Conventional | Modified | Conventional | Modified | Conventional |
| 15.19      | 426.60         | 464.93 | 1.02      | 7.67        | 0.12      | 8.92        |
| 17.15      | 426.06         | 456.28 | 1.75      | 10.85       | 0.01      | 10.47       |
| 19.11      | 426.24         | 453.16 | 0.91      | 13.63       | 0.18      | 9.17        |
| 21.07      | 425.97         | 440.15 | 1.42      | 4.42        | 0.22      | 10.86       |
| 23.03      | 427.87         | 445.49 | 0.84      | 15.87       | 0.30      | 6.28        |

From table 1, it appears that the frequency value produced by the modified sonometer is more accurate. This can be seen from the relative error value between the modified sonometer and the conventional one. The maximum relative error of the modified sonometer is 0.30%, while the conventional error is 10.86%. To make it easier to do the analysis, the data in table 1 are plotted in a graph as shown in figure 4.

**Figure 4.** The graph between the frequency and voltage of the strings

The error bars in figure 4 are taken from the standard deviation values. It appears that the frequency produced by the modified sonometer is more precise. It can be seen that the error bars are much shorter than the frequency error bars produced in a conventional way. It also appears that the frequency value produced in a conventional way is far from the actual value (tuning fork frequency, 426 Hz) while the frequency produced by the modified sonometer is close to the actual value. Thus, the sonometer combined with the LM567 frequency sensor module and the microcontroller can work as expected.
4. Conclusion
We have designed and made a microcontroller-based sonometer. Compared to the conventional sonometer, the microcontroller-based sonometer produces more accurate and more precise frequencies. The maximum relative error of this sonometer is 0.30% while the maximum relative error of conventional sonometer is 10.86%.

6. References
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