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# Development of measurement system using on-line software for shear horizontal surface acoustic wave sensor

# 横波型弾性表面波センサのためのオンラインソフトウェアを利用した測定システムの開発

Naoki Maekawa†, Jun Kondoh (Shizuoka Univ.)
前川直毅†，近藤淳（静岡大学大学院総合科学技術研究科）

## 1. Introduction

In medical fields, a real time measurement is important to obtain quick responses. Point of care testing (POCT) is a real-time inspection system that is used near patient in the medical field[1]. It is a useful method to an early diagnosis. When a POCT is combined with the internet, it is possible to realize an online inspection system which can be used anywhere.

A delay-line type surface acoustic wave (SAW) sensor consists of interdigital transducers (IDTs) and propagation surface. A feature of the SAW sensors are simultaneous detection of mechanical and electrical properties of an adjacent medium on a SAW sensor at the same time. When a shear horizontal-SAW (SH-SAW) is used, a liquid-phase sensor is realized[2]. The SH-SAW sensor has been applied to a biosensor for POCT applcation[3, 4].

To realize a sensor for POCT applications, it is required a “disposable, inexpensive, small, and robust” sensor chip and a diagnostic device. The SH-SAW sensor satisfies this condition and is suitable for POCT. In this study, we developed a measurement system using on-line software for SH-SAWs.

## 2. Measurement system

**Fig. 1** shows the proposed measurement system in this study. The system will be applied for wireless measurements, when antennas are inserted instead of the directional coupler. The sinusoidal signal generated from the signal generator is divided two signals. One is connected to an oscilloscope for reference signal and the other is to the SH-SAW sensor. The sinusoidal signal for the SH-SAW sensor is also divided into clockwise and counterclockwise directions. The counterclockwise signal is converted to SH-SAW by IDT1 and becomes an electrical signal again at IDT2. The clockwise signal is the opposite. The two signals become one at the power combiner. Then the combined signal was measured by the oscilloscope.

kondoh.jun@shizuoka.ac.jp

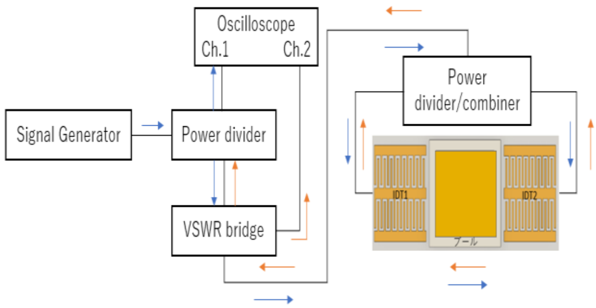


Fig. 1 Measurement System proposed in this study.

## 3. Analysis program

In this study, we developed a measurement system using an on-line software. By using the on-line software, it is possible to analyze the measurement data on the web. The advantage of this method is to use the software at "anyone, anytime, and anywhere". In addition, by incorporating a program that automates analysis, it is possible to obtain analyzed results "accurately, precisely, and quickly". Therefore, development of the on-line measurement system is suitable for POCT. The software used in the analysis is “Google Collaboratory”.

**Fig. 2** shows a block diagram of the analysis program. With this program, the amplitude ratio and phase difference that are the analysis data can be acquired from the measurement data. The heterodyne is used to calculate the analysis data.

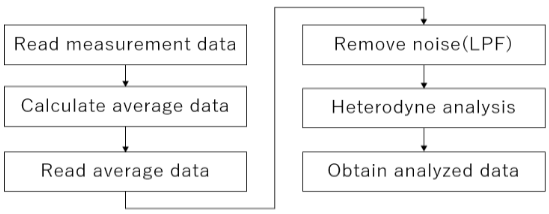


Fig. 2 Block diagram of analysing method.

## 4. Comparison of phase measurement method

In this research, amplitude and phase are measured. The amplitude is obtained by averaging the maximum and minimum values of the sinusoidal signal. The phase is obtained from the zero-cross, heterodyne, and lock-in methods. In this study, three measurement methods were experimentally compared using a measurement system shown in Fig. 1. The 155 MHz SH-SAW sensor was used for the measurements. Sample solutions were glycerol and water mixtures with different concentrations. Reference liquid was distilled water. The obtained results were compared with the exact solution. Three methods were used to obtain the phase difference. The results are plotted on **Fig. 3**. From the figure, it is found that the heterodyne and lock-in methods agree with the exact solution. The accuracy of the heterodyne and lock-in methods is almost the same. The heterodyne method has simpler calculation process than the lock-in method and is easy to program. Therefore, the heterodyne method was chosen as the optimum method.

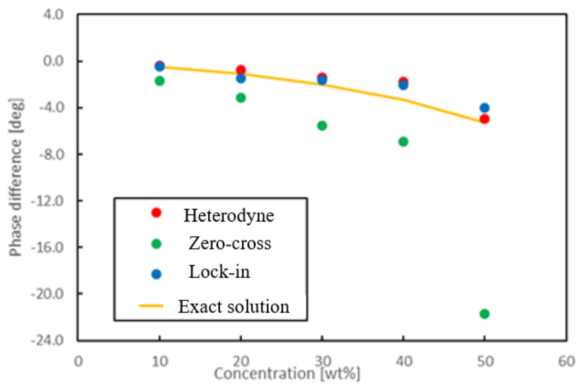


Fig. 3 Phase difference comparison

## 5. Analysis results and examination

The reference and measured signals obtained by the oscilloscope were multiplied and DC component was extracted. **Fig. 4** (a) shows the extracted DC signal. As a high frequency signal is superimposed as noise (see Fig. 4 (b)), low pass filter (LPF) was used to remove the noise. The results are shown in Figs. 4(c) and 4(d). From the DC signal shown in Fig. 4(c), the phase was obtained.

Obtained results of the phase difference and amplitude ratio between the reference and measured signals are compared with the exact solution as shown in **Fig. 5**. The phase difference shows the same tendency with the exact solution. The amplitude ratio almost agrees with the exact solution. The exact solution was obtained for the Newtonian fluid. At high concentration, it is necessary to consider the influence of viscoelasticity. Therefore, reasonable results were not obtained with the on-line software.

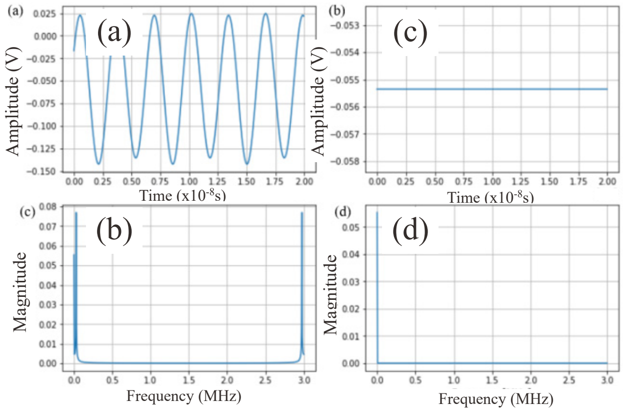


Fig. 4 (a) Output DC signal, (b) FFT of (a), (c) after LPF passed, (d) FFT of (c)

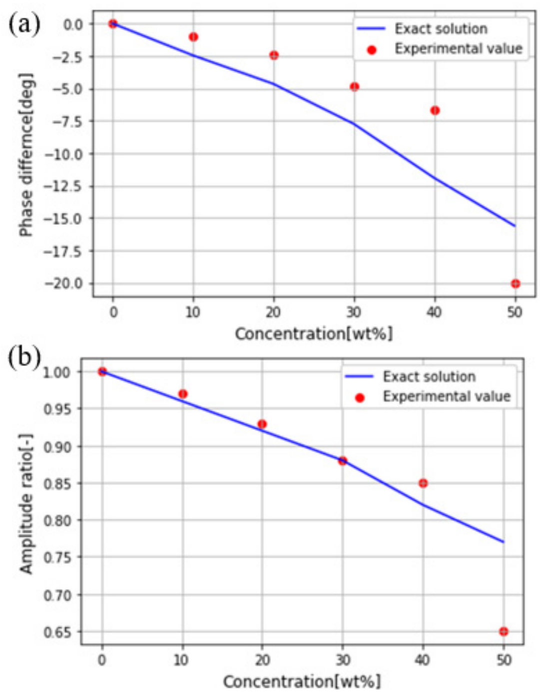


Fig. 5 Analyzed results. (a) Phase difference and (b) amplitude ratio. Solid line is the exact solution.

## 6. Conclusion

In this study, we developed a measurement system using on-line software for the SH-SAW sensor. The analyzed results agree with the exact solution for both phase difference and amplitude ratio are considered applicable to measurement. In the future, the proposed method will be applied for wireless measurement.

**References**

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