Introduction

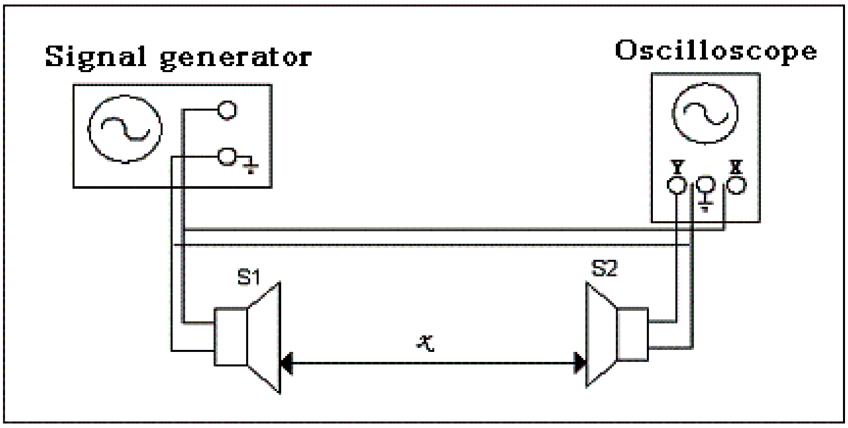
Sound is defined as longitudinal mechanical waves in some media. Audible sound refers to the frequency range from 20Hz to 20kHz while ultrasound refers to that higher than 20kHz. It is convenient to measure the speed of sound with ultrasound due to several advantages such as short wavelength and easy directional emission.

The speed of ultrasound depends on the properties and phases of media. Therefore, the information of sound speed helps to study the properties of the media and it is of practical importance in industrial production. For example, it is applied to measure the concentration of gas or liquid, the specific gravity and the interface of different oil in the pipelines.

In this experiment, the speed of ultrasound propagating in air is measured with the help of piezoelectric transducer.

Theory

Similar to the other types wave, the speed of ultrasound wave relates to its frequency and wavelength by $v = f\lambda$. Therefore, the speed can be determined by measuring frequency and wavelength. In this experiment, the frequency of ultrasound is controlled by a signal generator which drives a piezoelectric transducer to emit ultrasound. For the measurement of wavelength, both standing-wave (resonance) method and traveling wave (phase comparison) method can be applied. The experiment setup is shown as below:



1. Measure wavelength by standing-wave method

Consider a one-dimensional wave sinusoidal wave is reflected by a hard wall normal to the propagation direction, the longitudinal displacements of the propagating wave and the reflected wave at time t and point x are mathematically expressed as

$$y_1 = Acos2\pi(ft - \frac{x}{\lambda}) \tag{1}$$

$$y_2 = Acos2\pi(ft + \frac{x}{\lambda}) \tag{2}$$

respectively, where A, f and λ denote the amplitude, the frequency and wavelength respectively. The overall wave function is

$$y = (2Acos2\pi X/\lambda)cos2\pi ft \quad (3)$$

It shows the maximum amplitude resides at points

$$X = \pm n\lambda/2 \qquad n = 0,1,2,3 \dots\dots \quad (4)$$

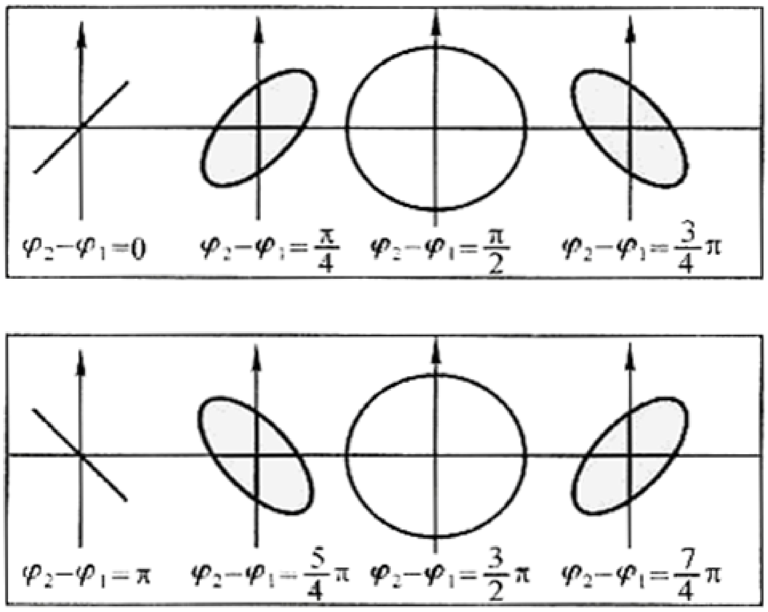
which are called antinodes. In comparison, the minimum amplitude resides at points

$$X = \pm(2n+1)\lambda/4 \qquad n = 0,1,2,3 \dots\dots \quad (5)$$

which are called nodes. Therefore, the wavelength can be determined by measuring the displacement of two adjacent nodes or antinodes.

2. Measure wavelength by phase comparison method.

There are two piezoelectric transducers in this experiment which act as source S1 and sensor S2 respectively. Consider a sinusoidal wave emitted at S1 and detected at S2, the phase different at any time is $\varphi = 2\pi x/\lambda$ between S1 and S2 with x their distance. It shows the phase difference changes by 2π when the distance varies by a wavelength. With help of Lissajour curve, the wavelength can be determined through the phase.



Contents

1. Adjust the experimental setup to work in the best state. The resonance frequency of transducer is about 35kHz.
2. Measure wavelength and sound speed by the standing-wave method.
3. Measure wavelength and sound speed by the phase comparison method

Notices:

1. Make sure that S1 and S2 are parallel.
2. Adjust the signal frequency of signal generator to the resonance frequency of piezoelectric transducer.