THE INSTITUTE OF ELECTRONICS,
INFORMATION AND COMMUNICATION ENGINEERS

IEICE Technical Report
PEM2015 FB-2/FCA-2 (2015-11)

Preliminary Measurement with Laser Microphone for Acoustic Noise Due to Electromagnetic Vibration

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Abstract It is necessary that the method to measure sound waves generated from the magnetic field exposure system for biological experiment. Generally used microphones, such as dynamic-microphone and condenser-microphone, are not suitable for the measurement because they are affected by the magnetic field. Therefore the sound wave measurement method using optical system with laser is examined. We performed a preliminary experiment to detect sound waves emitted from a loudspeaker. Sound waves at 300 Hz and 80 dB SPL are detected by the sound wave measurement method using optical system with laser.

Keywords Laser Microphone, Sound, Magnetic Field, Biological Exposure System.

1. Introduction

The magnetic field exposure experiment using the rat is carried out for the evaluation of the safety of the magnetic field in the intermediate frequency band (300 Hz – 10 MHz) [1]. The exposure system generates unwanted vibration sounds, which may have an extra influence on the rat. For instance, it was reported that a mild biological change might happen by the ultrasound exposure [2]. Therefore it is necessary to measure these vibration sounds. However, generally used microphones, such as dynamic-microphone and condenser-microphone, are not suitable for the measurement under the condition close to magnetic field generation coil, because the existence of time varying magnetic field induces voltage within the microphone system. The purpose of this experiment is to apply a laser microphone to the measurement of the electromagnetic vibration sound.

2. Preliminary experiment for the sound detection

2.1 Theory of laser microphone

Our developing laser microphone system is based on the theory described in Ref. [3] and [4]. The block diagram of this experiment is shown in Fig.1. In this system, the interferometric self-mixing effect [3] for the semiconductor lasers is used. The laser beam was collimated by a lens and was irradiated toward a mirror. The laser diode (LD) includes a photodiode (PD). The laser beam, via sound fields, reflected from the mirror interferes with a directory emitted laser beam by the LD. The wavelength of the laser, through the sound field, is changed by the refractive index change caused by the compression wave of sound. Therefore, the interfered laser beam detected by the PD changes according to the distribution and the compression ratio of sound wave. This measurement method depends on the interferometric self-mixing effect and is not affected by the magnetic field. Therefore, this method is suitable for the measurement of the vibration sounds generated from magnetic field exposure apparatus.

2.2 Experimental setup

We performed a preliminary experiment to detect the sound emitted by a loudspeaker. The laser diode is an HL7859MG manufactured by Hitachi, Ltd. The mirror is a TFAG-12.7C05-10 manufactured by SIGMAKOKI CO. The lens is a biconvex lens manufactured by KOYO CO. The current/voltage conversion circuit converts the electric current detected by the photodiode. In addition, a filter circuit and an amplification circuit are used. Operational amplifiers of NJM4580 manufactured by New Japan Radio Co., Ltd. were used for three

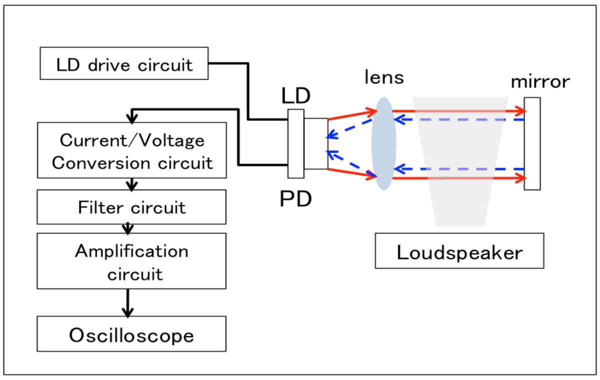

Fig. 1 The Block diagram of the laser microphone.

circuits to process high frequency signals up to 200kHz in the future work. Currently, low frequency signals are used in this preliminary experiment. A sinusoidal wave of 80 dB SPL, 300 Hz is emitted from the loudspeaker. The detected signals were observed by the oscilloscope of wave surfer 452 manufactured by Teledyne LeCroy Japan Corporation.

2.3 Results and conclusions

The detected signal observed by the oscilloscope is shown in Fig. 2. The observed signal has a frequency equal to the sound wave frequency of 300 Hz. A sound wave of 80 dB SPL yielded a voltage of $3V_{p\text{-}p}$. However, the detected waveform was distorted by the influence of circuit and background noise.

In the future work, this setup will be improved for the detection of sound waves of small amplitudes and higher frequencies up to 200kHz.

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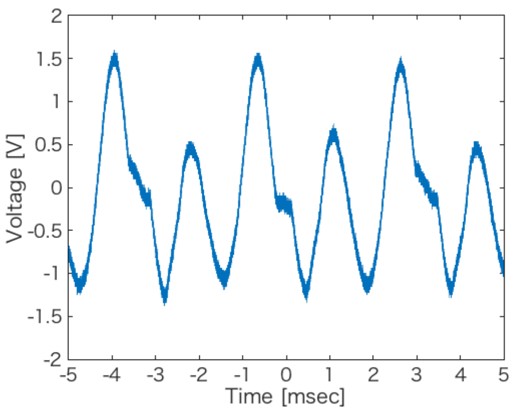

Fig. 2 The detected signal by the oscilloscope.