Abstract

The present work investigates a novel optical microphone without membrane for the detection of sound waves in air. This electroacoustic transducer MEOS (micro-electro-optical system) is based on a Fabry-Pérot etalon, consisting of two plane-parallel, partially transmissive mirrors. The light transmitted by the air-spaced etalon is a function of the refractive index of air, and is therefore pressure dependent. At the inflexion point of the Airy transmission function, light transmission shows linear dependence on sound pressure to a first approximation.

Conventional capacitor microphones as well as optical microphones used today are based on moving parts, usually a membrane. With state-of-the-art devices, high linearity as well as good signal-to-noise ratio are achieved. However, several drawbacks are inevitable in mechanical devices: The need of a quasi-linear membrane displacement gives rise to a number of design constraints concerning material composition and geometrical structure. Furthermore, mechanical devices are sensitive to mechanical disturbances, known as body noise. The transducer examined in the present work employs acousto-optic interactions exclusively. In this design, no membranes are required. Therefore, the sensor has a high mechanical stability and shows low body noise susceptibility.

In an experimental setup of the optical microphone MEOS, measured changes of light transmission correspond well with the values predicted by calculations based on the change of refractive index. Therefore, influences of mirror vibrations can be neglected. Two types of laser diodes, VCSEL (vertical-cavity surface emitting laser) and DFB (distributed feedback laser), are investigated with respect to their suitability. A feedback loop for laser frequency stabilization is designed. By means of a balanced signal detection scheme, quantum noise limit is reached.

Signal-to-noise ratio, dynamic range and harmonic distortion are calculated for diverse scenarios and are measured in two different experimental configurations. The influence of design parameters such as the size of the etalon air spacing, the mirror reflectivity and laser power and wavelength are investigated in respect to a future miniaturization of the microphone. Various noise sources imposing a potential limitation on microphone performance are theoretically investigated and measured experimentally. For aural evaluation of the optical microphone without membrane, music and voice recordings were made.