Proposed Method for Chemical Detection Using Photoacoustic Spectroscopy and Acoustic Beamforming

Aurelius Graninger[1], Fow-Sen Choa[1]
[1] University of Maryland, Baltimore County, Baltimore, MD 21250, USA
email: choa@umbc.edu

In recent years many advances have been made in the area of gas detection, especially with the advent of the Quantum Cascade Laser. However, many methods of detection require that the gas be at the location of the sensor, contained in a chamber. Here we propose a new method for standoff chemical detection that combines photoacoustic spectroscopy and acoustic beamforming. Photoacoustic spectroscopy is a proven method for gas detection presently employed in systems such as FTIR that takes advantage of a molecule's excitation via certain light wavelengths to detect its presence. Acoustic beamforming is a technique that allows one to listen in to a specific point in space while cancelling external noise; this will allow us to detect signals from a remote location, rather than a contained location next to the sensor.

Our system, as shown in Fig. 1, will be comprised of two microphone arrays, each forming a beam that converge at one point. This will allow us to listen in to one exact point as opposed to a planar channel. Two tunable Quantum Cascade Lasers will then pointed at the crosspoint of the acoustic beams and modulated so that their wavelengths match the vibrational energy of the molecule at the location. The microphone arrays will then be able to detect the pressure waves emanated from the molecule as a result of the photoacoustic effect, and the signals will be sent to a Field Programmable Gate Array (FPGA) to apply beamforming techniques and process the acquired signals. The electrical setup of the microphone array is shown in Fig. 2, which consists of an amplifier and an analog to digital converter. Weighted delay and sum beamforming will be incorporated which allows relocation of the acoustic beams by simply changing the phase of each microphone. Thus, by changing the crosspoint of the QCLs, and by using the FPGA to change properties of the acoustic beams, the array's focal point can be dynamically changed. By tuning the laser wavelength, we can identify a gas molecule species, and by moving the focal point, the density of the molecule's presence can be mapped.

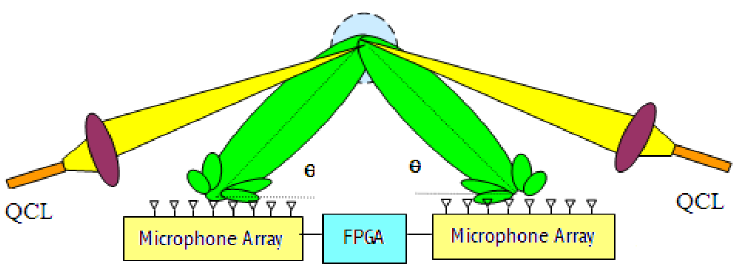

Fig. 1. The standoff photoacoustic detection system

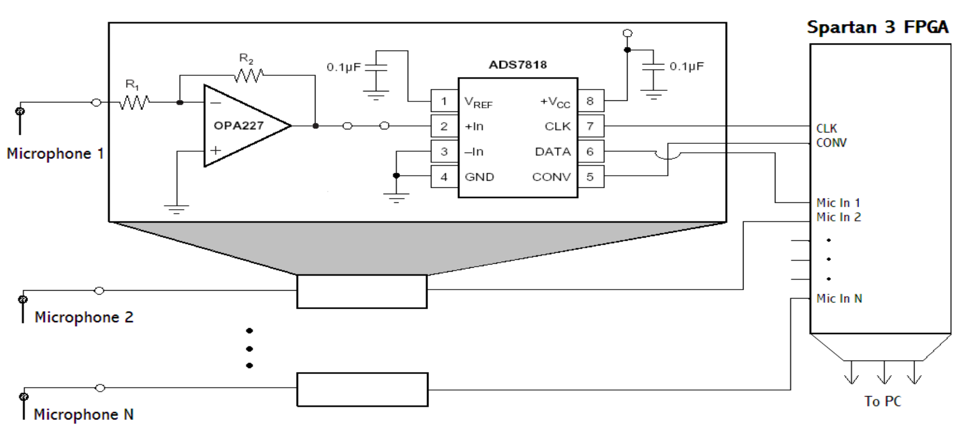

Fig. 2 Detailed array beam-former implementation.