Design of an Optimal Analogue Microphone System for Best Possible Capture of Incoming Acoustic Signals

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Abstract

This project examines how to achieve the best possible capture of audio in a surveillance camera without overspending. This is done by designing a complete analogue microphone system to be integrated in a surveillance camera and identify the critical stages in terms of performance. This project covers evaluation of mechanical designs to eliminate undesired acoustic effects, choice of an optimal microphone, design of analogue signal processing such as amplification, filtering and signal level adjustments, evaluation of an optimal signal path for minimal interference and evaluation of an analogue-to-digital converter.

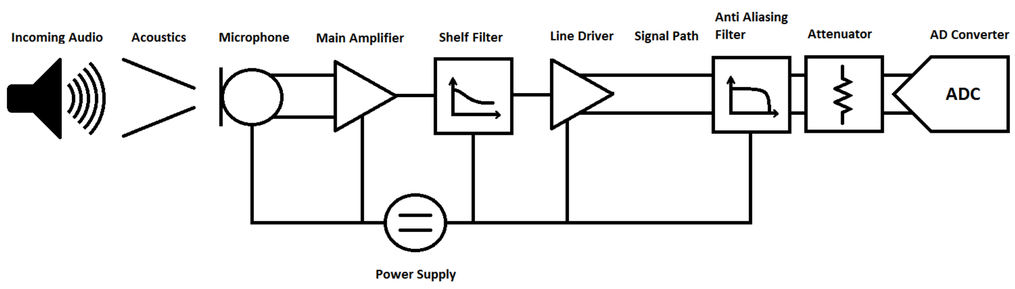

Figure 1: The complete microphone system.

Microphone

The microphone is the most critical component in the system since this sets the performance floor. Therefore, it is important that the microphone is chosen with care to suit the surveillance application. The specifications that is considered most important is signal to noise ratio (SNR), Total Harmonic Distortion (THD), sensitivity and frequency response. After measurements the Invensense ICS-40720 microphone were chosen. The frequency response can be seen in figure 2.

Acoustics

The acoustic design is critical when trying to achieve high sound quality. An improper mechanical design can have a devastating effect on the performance. The task is to get the acoustic signal to the microphone without distorting it. Ways of eliminating the acoustic effects, such as funneling the tube and using a Helmholtz resonator, have been tested and it becomes obvious that tuning such an implementation would be very hard, especially in such small dimensions. Therefore, the best way of reducing the acoustic effects is to place the microphone as close to the chassis as possible to reduce the length of the transmission line which will theoretically eliminate the acoustic effects.

Even with the theoretically ideal solution of a short acoustic transmission line there will be significant acoustic effects (see the difference between "Microphone" and "In Camera" figure 2).

Analogue Signal Processing

The analogue signal processing consist of a low noise, low distortion pre-amplifier with a variable gain of $6dB - 45dB$ to get the desired amplification without deteriorating the sound quality. Filtering consisting of a shelf filter to get a flat frequency response for low frequencies (see figure 1) and a low pass filter to eliminate noise outside the audible range which can cause unwanted effects in the analogue to digital conversion. A line driver that safely transport the signal across the camera. Finally a signal attenuator to adapt the signal to the analogue-to-digital converter.

Power Supply Regulation

A noisy power supply can cause noise on the signal or spontaneous circuit oscillations. To remove unwanted noise the power supply is filtered using large capacitors that attenuates high frequencies.

Analogue-to-Digital Converter (ADC)

The ADC used is the Analog Devices ADAU1361 which is operated at with a $48\ kHz$ sample rate and $16 - bit$ resolution. This will produce CD quality audio which will be enough for this project.

Results

Every part of the microphone system is connected together and placed inside the camera and measured to obtain the specification of the complete microphone system (see table 1 and figure 2).

Specification	Measurement
SNR (dB)	67.07
THD $\%$	0.75

Table 1: Measured specifications of the complete microphone system.

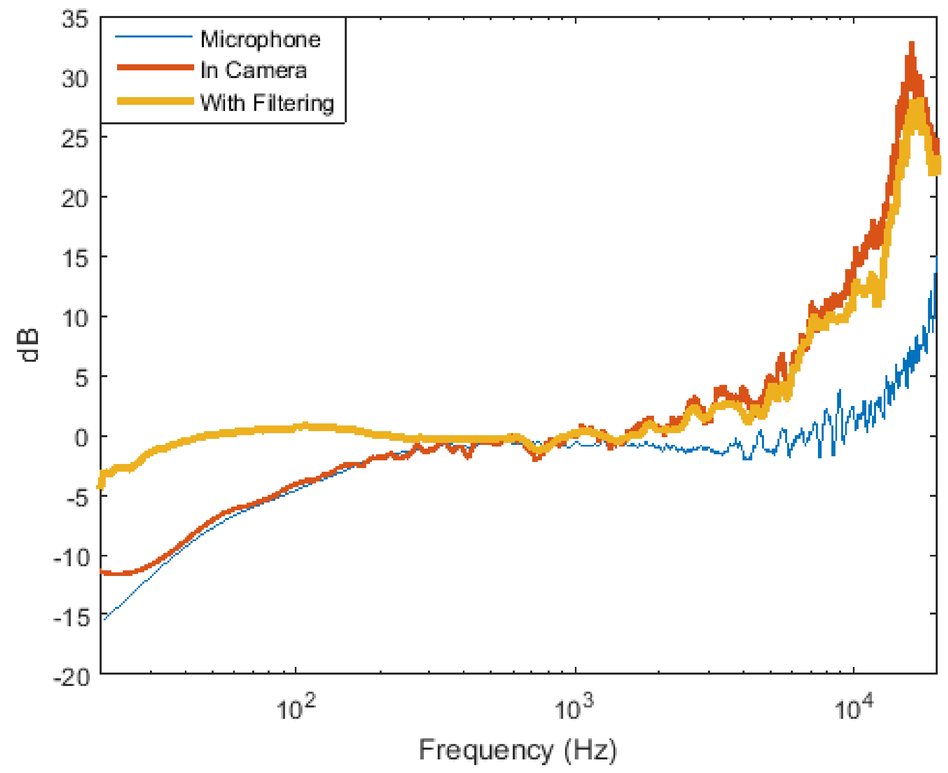

Figure 2: The measured frequency response of the microphone as a standalone component, microphone inside the camera and after filtering.

Conclusion

The measurements show an outstanding SNR which makes it possible to detect sounds from very far away, the THD is well below 1%, which can be considered inaudible, and the frequency response is flat for low frequencies and has a peak for high frequencies which may be desired when listening to sounds far away since high frequencies are more easily attenuated.