Acoustic Noise Elimination by FPAA

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Abstract: From ergonomic and physiological point of view a quiet, almost noiseless environment is necessary. This can be implemented by means of passive or active noise filtering procedures. The essence of the passive noise filtering is the placing a noise absorbing device between the human ear and the undesired noise source. There are several procedures of active noise capturing or decreasing. In this article we deal with the procedure using inverted phased signals to suppress the noise waves in a certain point by means of an actuator.

Keywords: noise elimination in acoustic space, FPAA, active noise elimination, actuator, noise microphone, control microphone

1 The Choice Elimination Effect in Noise Space

If we want to set up a physical model, we have to take into consideration to directions of signal spreading: one from the noise source to the observed point, (1, 2) the other signal spreading way, obviously from the actuator loudspeaker to the observed point. The sound spreading speed in the air is known, so this way, from the phase difference or from the different spreading time, the phase push between the actuator diffuser and the observer can be defined and measured.

$$t_d = t_{ns} - t_{nm} - t_{as} \qquad (1)$$

Where: t_d: total shift time, t_{nm}: time to noise source to noise microphone, t_{as}: time to actuator loudspeaker to silent microphone, t_{ns}: time to noise source to silent microphone to silent microphone

$$A_p = A_n - kA_n(t_d) \qquad (2)$$

Where: A_p: noise amplitude in suspected point, A_n: noise amplitude in suspected point,
k: ratio of amplifying

This sort of noise suppressing can be applied in an acoustic space, where the investigated point (the creation of zero value suppressing environment) can change, assuming that in a large acoustic space the source of noise is point like emerging from one point and theenvironmental noise in the surrounding of the studied person should be reduced to zero. On the Figure 1 seen the idealized acoustical-, and structural arrangement.

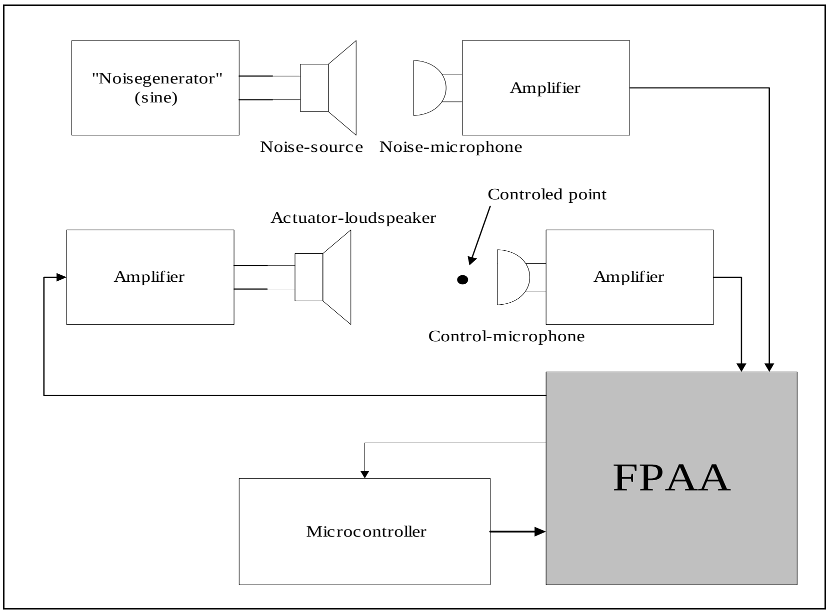

Figure 1

The acoustical-, and structural arrangement

If the acoustic space is appropriate to this model, the noise value can be eliminated efficiently from this point.

For the above mentioned procedure we use a free programable analog array (FPAA), which basically consists of a changeable time-shift filter and an amplifier inverter capable of changing amplification. A microcontroller and a FPAA electrical circuit is used for achieving this.

2 Electronically Realisation of the Noise Elimination

In the procedure seen in the figure we placed a sensor (noise) microphone in the vicinity of the noise source. This signal is amplified then, after inverting it, it is amplified again driven through a phase pusher, then driven to the actuator diffuser. The actuator loudspeaker is placed close to the point to be observed. The performance of this actuator loudspeaker is high enough to sense and cheque the zero acoustic pressure at the control microphone (ideally placed in the zero noise pressure point). The value of noise pressure and the phase difference should be changed so that the signal sensed on the control microphone should be of the lowest amplitude.

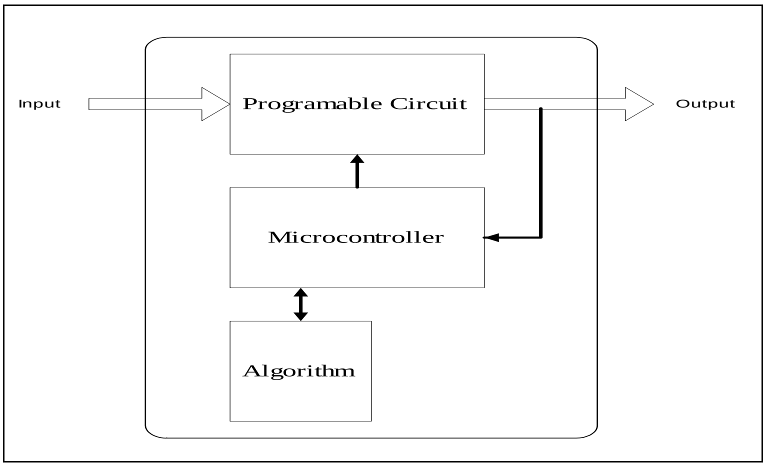

Figure 2

A re-programmable FPAA-MCU cell in

The equipment created this way is basically a freely programmable analogue cellblock electrical circuit (FPAA) connected to a microcontroller. (Figure 2) The connection of the microcontroller and the FPAA electrical circuit allows the creation of such a dynamically re-configurable (adaptive) electrical circuit which is capable of changing the value of the phase shift and amplification according to the desired function. (Figure 3)

The main point of the procedure is the algorithm by the help of which we try to create zero sound pressure in the surrounding of the control microphone.

The distance between the two microphones placed in the system (noise microphone and control microphone) and the speed of the sound spreading gives the time of signal spreading. Measuring this we can define the value of the phase push. (2.)

For defining the signal delay we use the acoustic signal released from the noise source. By the help of auto-correlation we define the delay.

In this case we drive the signal into the actuator without inverting. (Fig. 4.) The phase push is increased as high as the signal on the microcontroller should be the highest possible.

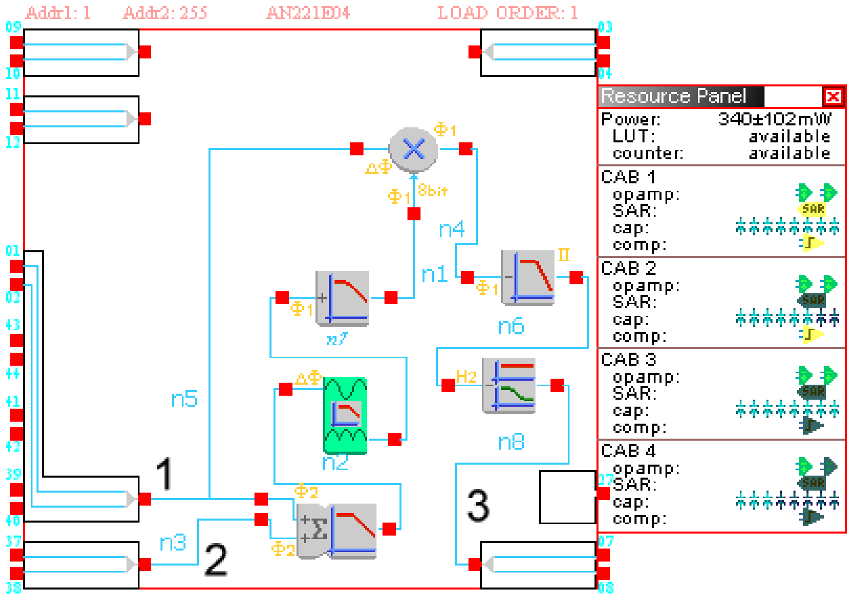

Figure 3

The inner structure of FPAA

For example by the peak-detector circuit in FPAA. Afterwards we just have to adjust /adapt the amplitude of the inverted signal. Other solution could be the situation when a noise impulse is produced with the actuator diffuser and this impulse is sensed with the control microphone and with the noise microphone. The produced noise impulse arrives first at the control microphone then it initiates the noise microphone placed at some distance. In this case we have to measure the time between the two signals which is synonym to the phase push.

By the help of this procedure we can achieve that the delay and the suppressor signal should produce exactly zero sound pressure at some distance from the noise source.

During the experimental procedure the signal appearing in the actuator loudspeaker generally produced zero sound pressure in the environment of the control microphone within a few ten milliseconds. Figures 5 and 6 shows the experimental units and their measuring result.

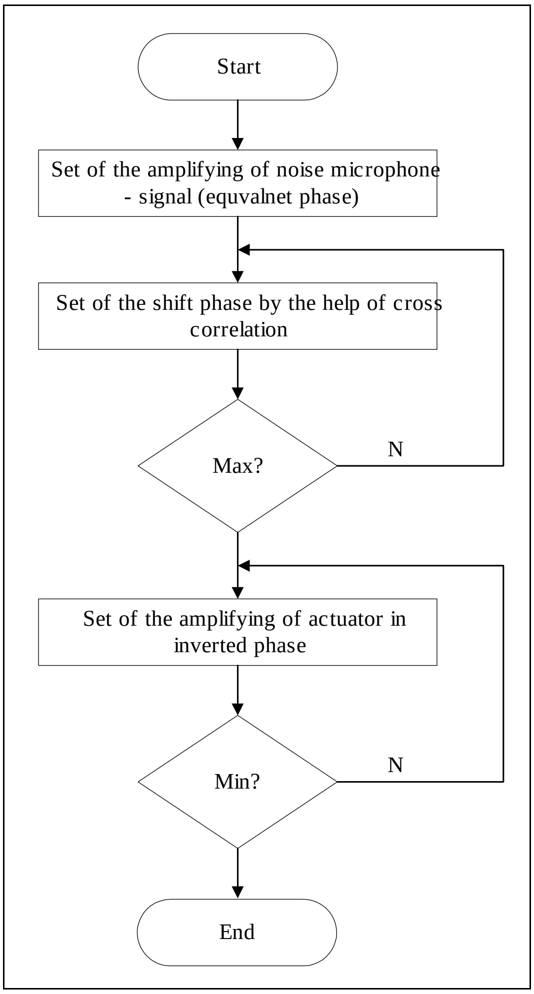

Figure 4

One art of correct amplitude fitting algorithm

Figure 5

The coo-work MC and FPAA in measuring environment,
Noise source loudspeaker, microphones, and actuator-loudspeaker

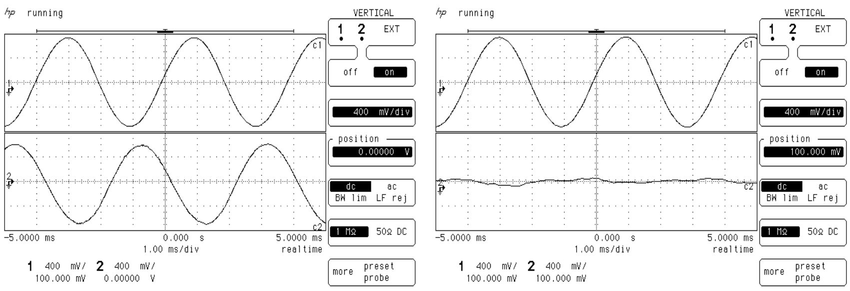

Figure 6

On left up, the "noise" signal and actuator-signal, on right up the "noise" signal and "silent" signal

Conclusions

The suggested arrangement and algorithm could be a procedure for the implementation of automatic noise elimination. More efficiency result we would like to get by the sophisticated algorithm, when in the suspected point the position changing is relative slow.

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