한국소음진동공학회 2011년 추계학술대회논문집, pp.115~119

Evaluation of low cost electret microphone performances for active noise control barriers

AndreyG Troshin† · ChaSangGon* · Kim DongHwan** · Shin EunWoo***

Key Words: Active Noise Control, SMD microphone, active noise control barrier, wind test, coherence function, FxLMS algorithm, FRF.

ABSTRACT

Instead of very expensive sound record and professional measurement microphones the low cost Surface Mounted Device (SMD) microphones are proposed for practical barrier ANC system. FRF of the microphones and theirs sensitivity to the wind interferences are evaluated in semi anechoic chamber. The improvement of feedforward algorithm noise reduction index was evaluated based on measured coherence function between tested SMD and reference microphone. Test was performed at various wind speed from 1 m/s to 5 m/s.

1. INTRODUCTION

The active noise control technology requires appropriate acoustic hardware like error and reference microphones and control loudspeakers with power amplifiers (1), (2). Using feedforward algorithms which are most popular nowadays the reference microphone or reference sensor serves for providing the electrical signal proportional to primary acoustic or vibrational field. The error signal is utilized to adjust the quotients of adaptive filter in order to minimize the residual acoustic field in the quite zone. The ᄀ high cost of the outdoor professional microphones as well as sound recording studio microphones does not allow to make a whole ANC product for affordable price. Despite the very big achievement in DSP industry with significant progress in digital signal processing and growing the computational power of modern processors the high cost of microphones and other acoustic components sill limits the development of ANC technology from pure research to real practice. Also an implementation of the ordinary general purpose microphones like DJ dynamic or capacitive ones for studio recording can not be made by two reasons. First those microphones design does not provide the same specification for hostile outdoor environment like dust, rain wind and show. Second reason which was mentioned above is relatively high cost of them. For example electret recording microphone average price is 150 $ while specially designed high precision models for outdoor noise monitoring costs several thousand dollars.

Nowadays the MEMS and SMD (surface mounted device) component technology becoming very popular in automated industrial systems. Moreover electronic companies suggest the MEMS sensors for very affordable prices

† 교신저자 : 정회원, SQ 엔지니어링㈜
능동소음제어시스템 기술개발 연구단
E-mail : andytroshin@gmail.com;
Tel :010-9926-1961
* , **, *** : SQ 엔지니어링㈜
능동소음제어시스템 기술개발 연구단

comparing to high fidelity products. Therefore it is very useful to evaluate commercially available SMD microphones as a part of active noise control system.

After searching the appropriate one of the SMD Knowles Acoustic microphone was chosen (3). It has affordable price within 5$~10$ high sensitivity -18 ~-30 dB/Pa, built-in preamplifier and balanced audio output which is very suitable for balanced audio signal standard. Also the microphone capsule is very resistant to low and high temperature, mechanical shock and vibration, RF interferences and humidity up to 85%. Detail specifications can be found in reference (3). However the microphone capsule does not have the special wind protection enclosure.

2. SMD MICROPHONE TEST IN ANECHOIC CHAMBER

Testing set-up in anechoic chamber is shown in Fig. 1. The SMD microphone FRF sensitivity was measured used step sine signal with third octave band frequencies to verify the frequency range of interest which is usually from 50 Hz to 500 Hz. The sound pressure level was generated by ANC control loudspeaker designed by authors and monitored using sound level meter. The level was sustained as 94 dB (1 Pa) for every third octave band frequency. Measurement results are depicted in Fig. 2.

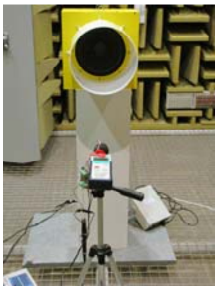


Fig. 1 SMD microphone test set-up in anechoic chamber

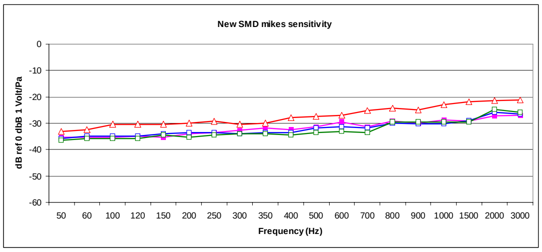


Fig. 2 Results of SMD FRF test: red color – sensitivity in balance signal mode, green, magenta and blue colors – sensitivity of the three different microphone samples in single output signal mode.

It can be seen from Fig. 2 that microphone FRF covers all frequencies of interest for ANC system and FRF is flat enough in the range from 50 Hz to 500 Hz that is typical frequency range for active noise control.

It means that from this point the SMD microphones are suitable for active barrier purposes.

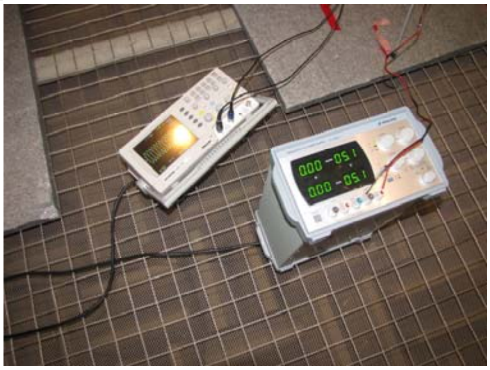
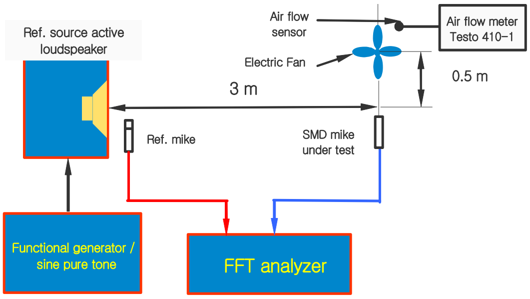


Fig. 3 SMD microphone sensitivity test in balanced signal mode vs. various power supply voltage.

The setup for testing the microphone sensitivity vs. various voltage of power supply is depicted on Fig. 3. It was found that microphone sensitivity was not changed across the voltage range from 1.5 V to 5 V.

3. EVALUATION OF THE ALORITHM REDUCTION INDEX WITH AND WITHOUT SMD MICROPHONE WIND PROTECTION DESIGN

Experimental arrangement for evaluation of influence of wind screen enclosure to noise reduction index of FxLMS algorithm is shown in Fig. 5. Measurement of the wind speed was monitored and narrow band analyses performed using 01dB FFT analyzer. After that the narrow ban data was post-processed to calculate coherence function between signal from reference microphone without wind interferences and tested SMD microphone subjected to wind with various speed. The measurement of the wind speed was performed using air flow test meter model TESTO 410-1.



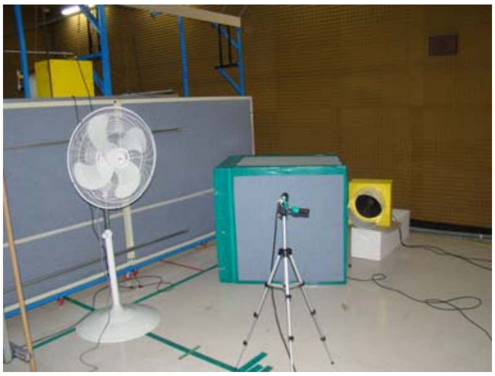
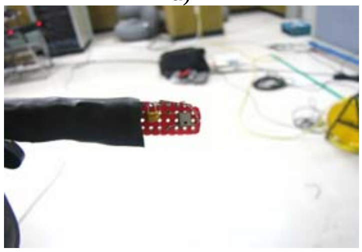


Fig. 4 Measurement set-up for testing sensitivity to wind interference

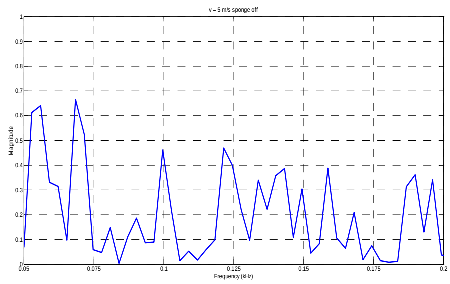
a)



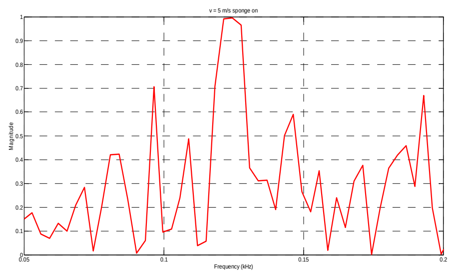
b)

Fig. 5 SMD microphone with a) and without b) wind protection enclosure

Typical example of coherence function for wind speed 4 m/s with and without wind protection enclosure is indicated in Fig. 6.



a)



b)

Fig. 6 Coherence function between reference microphone and tested microphone in windy environment (reference signal is pure tone 125 Hz wind speed = 5 m/s: a)-no wind protection enclosure b) -with wind protection enclosure

It can be seen from Fig 6 that enclosure is able to improve coherence function from 0.2 to 0.99 (Figure 6 b) and thereby could provide more better performances of the FxLMS algorithm like reduction index and converges because those performances are strongly dependant on quality of the reference and error signals (1), (2). Reduction index with and without wind isolation enclosure were calculated using formula proposed by Sen Kuo and D. Morgan (5).

as followings:

$$NR = -10 \cdot log_{10}(1 - \gamma^2_{ref.error}(f)) \quad (1)$$

Where: $\gamma^2_{ref.error}(f)$ – coherence function between error and reference signal.

Further on the NR indexes with NR_1 and without NR_2 enclosure were calculated according to Eq. (1). The calculated improvements of NR indexes as a difference $\Delta L = NR_1 - NR_2$ are depicted from Fig. 7 to Fig. 10.

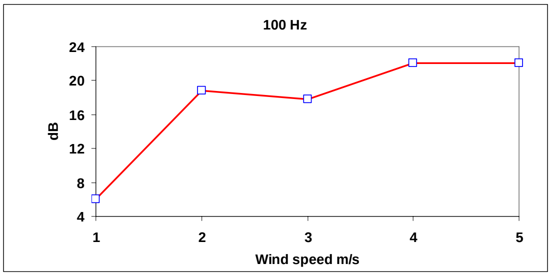


Fig. 7 Noise Reduction Index improvement for frequency 100 Hz vs. various wind speed

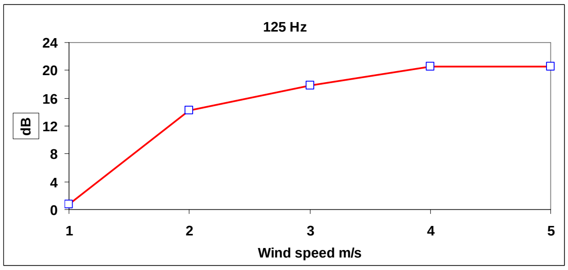


Fig. 8 Noise Reduction Index improvement for frequency 125 Hz vs. various wind speed

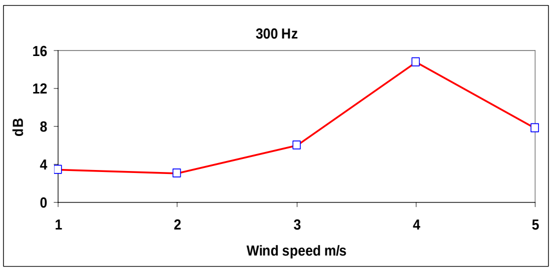


Fig. 9 Noise Reduction Index improvement for frequency 300 Hz vs. various wind speed

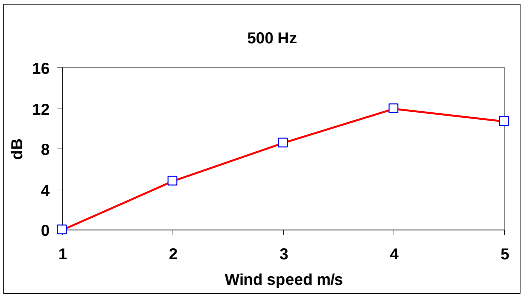


Fig. 10 Noise Reduction Index improvement for frequency 500 Hz vs. various wind speed

It can be seen from plots from Fig. 1 to 7 that at low wind speed 1 m/s the wind protection enclosure does not show high improvement for algorithm noise reduction index (4~6 dB). It can be explained that at low wind speed the influence of the wind is not so high to algorithm performances.

To demonstrate that the values of the noise reduction index with and without wind screen enclosure are collected to table1 for the case of tonal component 500 Hz.

Table 1 Algorithm reduction index with and without wind screen enclosure

Wind speed m/s	Reduction index without enclosure, dB	Reduction index with enclosure, dB	Improvement dB
1	27	27	0
2	22	27	5
3	23	32	9
4	10	22	12
5	12	22	10

However at wind speed values from 2 to 5 m/s the evaluated improvement of the noise reduction becomes high and ranged from 10 to 20 dB. Therefore the wind protection enclosure design is useful for error and reference low cost microphones.

4. CONCLUSION

The SMD microphones can be used instead of the high expensive DJ and sound recording microphone models in real active noise control systems like an active barrier and other outdoor applications in windy environment. It was found that frequency response of the microphone is good enough to cove the frequency range of interest in practical active noise control barriers. Also based on wind test authors revealed that with low wind speed below 1 m/s protection enclosure does not improve very much algorithm reduction index because at low wind speed the wind interferences do not impact much the algorithm performances.

However in the case of high wind speed above 2 m/s and higher the enclosure has to be used for improvement of the quality of the error and reference signals and noise reduction indexes of the FxLMS algorithm.

5. ACKNOWLEGEMENT

This research was supported by a grant (code 09 Construction Technology Innovation Program E05) from Construction Technology Innovation Program funded by Ministry of Land, Transport and Maritime Affairs of Korean government.

REFERENCES

(1) Colin H. Hansen. Understanding active noise cancellation. Spon Press, London and New York, 2001

(2) Scott D. Snyder. Active Noise Control. Primer AIP Press Springer, University of Adelaide, 2000.

(3) SiSonic microphone application note for model SPM0406HE3H-SB, www.knowles.com

(4). Julius S. Bendat, Allan G. Piersol Random Data: Analysis and Measurement Procedures, 4th Edition, 2010 by Wiley & Sons, ISBN 978-0-470-24877-5

(5) Sen. M. Kuo and D. Morgan Active noise Control Systems Algorithms and DSP Implementation, John Wiley and Sons INC.