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An Investigation on the Noise radiation of Lenovo F21 & F41 Laptops

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ABSTRACT

This work reports the measured data and relevant analysis on the noise radiation of Lenovo F21 and F41 laptops. Noise radiation of F41and F21 laptops and relevant fans are measured through standard desk test in accordance with ISO 7779. The measured data indicate that the fan and the laptop structure play an important role in the noise level of F21 and F41 computers. When the noise spectra for the fan installed respectively inside and outside the laptop are compared, it is evident the laptop structure reduces the fan noise in the high frequency range, while significantly increases it in the middle frequency range due to the acoustical resonance of interior cavity nearby the fan. At the low frequency range, the laptop structure has almost no influences on the fan noise because of the ineffective isolation and absorption for the low frequency noise.

1 INTRODUCTION

The noise radiation from computers has received increasing attention from IT industry. One of the main components being targeted is the cooling fan. Two classes of cooling fans can be roughly seen. One is axial fan while the other is centrifugal fan. Axial fans are usually equipped in desktop computers and have been investigated more widely than centrifugal fans used for laptops. Noise generation by axial fans has previously been studied theoretically or experimentally [1-3]. However, literature seems recording few studies on centrifugal fans and the comparison data of a centrifugal fan installed inside a laptop and outside a laptop haven't been reported. The centrifugal fan has an impeller, a diffuser and a circular casing. As the size of an impeller becomes smaller, its rotation speed needs to be increased to meet required performance specification and therefore the aerodynamic force applied on the impeller blades becomes severe. This unsteady aerodynamic force may generate excessive noise to the environments. Therefore the centrifugal fan used in a laptop is a major noise source due to its high rotation speed.

Current study is granted by the laptop company of Lenovo in China to analyze the noise radiation of their laptop products of F21 and F41 to strengthen their competition capacity in competitive laptop markets. This study presents the comparison of noise radiation level between an unattached fan and the same fan installed inside the laptop. The analysis for their difference in performance is given.

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2 EXPERIMENTATION

Fig.1 gives panorama of experimental configuration in accordance with ISO 7779 [4]. To conduct the test, a standard desk as illustrated in Fig.2 was built according to ISO 7779, where a detailed description of the desk is provided. In the test, the desk was set in a semi-anechoic chamber and the laptop and the fans were put on the desk, a microphone was placed in a certain distance, height and angle in reference to the desk as shown in Fig.1.

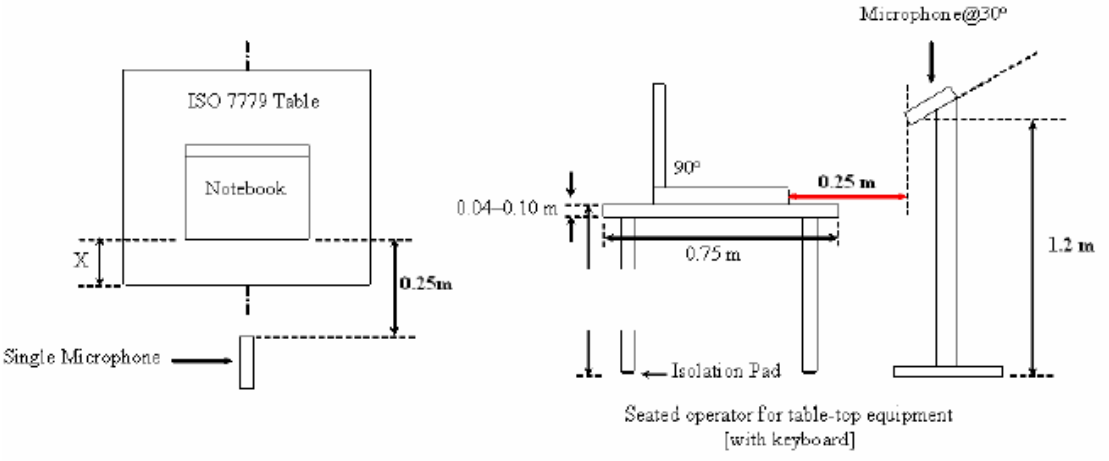

Figure 1: Illustration of Standard Noise Measurement of a laptop in accordance with ISO 7779.

Figure 2: Actual placement of microphone, laptop and standard desk during standard desk measurement of noise radiation of a laptop.

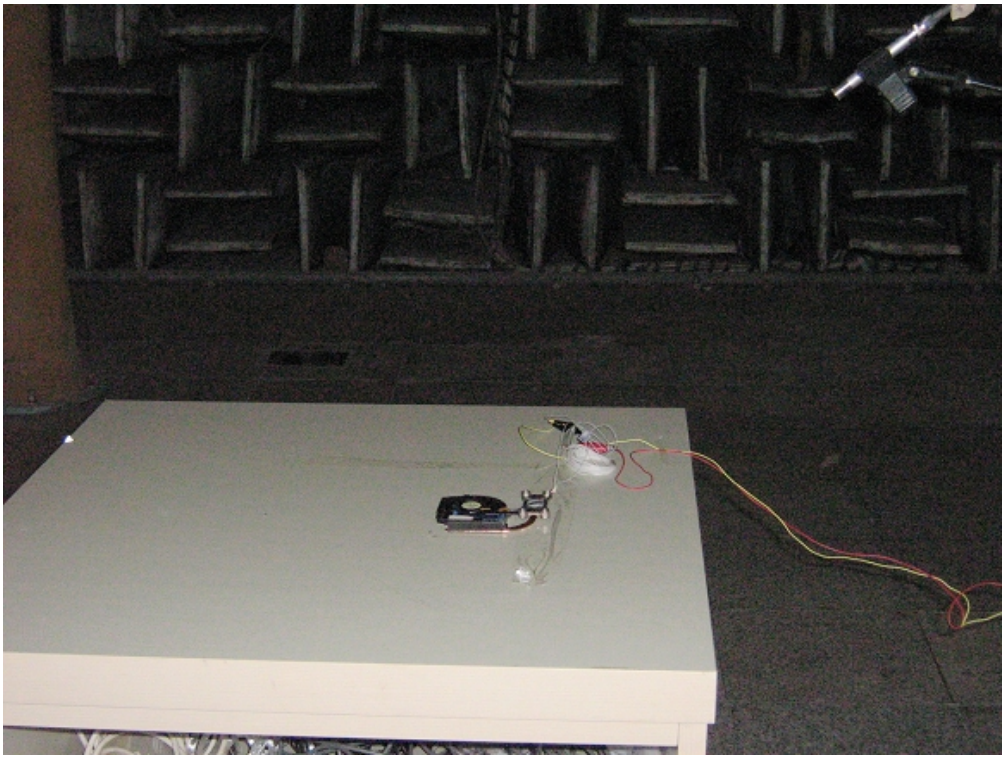

Figure 3: Actual placement of microphone, fan and standard desk during standard desk measurement of noise radiation of an unattached fan.

An example of test was shown in Fig. 2, where a laptop was set on the desk and the noise radiation was strictly measured in accordance with ISO 7779. The noise radiation of an unattached fan was also measured in a similar way as shown in Fig. 3.

During the test of noise radiation of a laptop, the rotation speed of the centrifugal fan inside a laptop is set to appropriate value by an application configured in the laptop provided by the manufacturer. For F21 laptops, the speed of the fan is set in the following values: 0 rpm (round per minute), 4200 rpm, 4600 rpm, 5200 rpm and 5800 rpm. For F41 laptops, the speed of the fan is set in the following values: 0 rpm, 2300 rpm, 2600 rpm, 2900 rpm, 3200 rpm and 3600 rpm. For the test of unattached fans, the input voltage of the fan was set to appropriate values to get identical rotation speed with that of laptop correspondingly. The input voltage was controlled by a constant voltage source.

3 RESULTS AND DISCUSSION

3.1 Experimental Results of F41 Laptop

Fig. 4 shows noise spectrum of a F41 laptop under the conditions of different fan speed. The linear and A-weighted sound pressure levels are also plotted for a comparison. Legends in the graph are used to represent different rotation speed of the fan except the sign of 3D, which refers to the case that the F41 laptop is automatically running a 3-dimentional game. In Fig.4, it is of interesting to notice that though the noise spectra increase with the rotation speed, the spectrum profiles under different fan speeds are very similar. The noise energy of the F41 laptop mainly stays in the frequency band between 500 Hz and 2000 Hz, and reaches maximum around 1000 Hz. The spectrum profiles are not sensitive to the fan speed implies that the cavity resonances may exist for the laptop noise radiation.

Fig.5 illustrates the noise spectra of an unattached F41 fan under the conditions of varied fan speed. Similar to the laptop noise in Fig.4, the sound pressure levels of the unattached fan increase with the fan speed. But unlike the laptop noise, the noise energy of the unattached

F41 fan mainly stays in the frequency band between 800 Hz and 5000 Hz and reaches maximum near 3000Hz. Furthermore, the spectrum profiles of the unattached F41 fan are varied with the fan speed, since the major noise band become narrower with the increase of the fan speed. When rotation speed reaches 3600 rpm, the sound pressure level of the unattached fan exceeds 35 dB.

In comparison the F41 laptop noise spectra with that of the unattached F41 fan at the same speed, Fig.6 shows that the noise spectra are rather different when the fan is unattached and installed inside the laptop. This indicates that the laptop structure have significant influence on the noise radiation. Since the high frequency is easy to be isolated, the laptop structure successfully reduces the noise radiation of the unattached fan above 2000Hz, and *vice versa*, for the low frequency is rather difficulty to be isolated, the laptop structure has almost no influence on the noise radiation below 200Hz. For the frequencies between 300Hz and 2000Hz, it is interesting to note that the laptop structure significantly increase the noise radiation of the unattached f41 fan, and around the frequency of 1000 Hz, the laptop structure magnifies the noise radiation to a maximum value.

The reason that the F41 laptop structure increases the noise radiation remarkably around 1000Hz is caused by the structure cavity inside the laptop, since it generates the relevant resonance. If absorption material is applied to the cavity artificially, the noise levers nearby 1000Hz can be sufficiently reduced. This implies that a possible way to reduce the laptop noise radiation could be achieved by removing the cavity resonance.

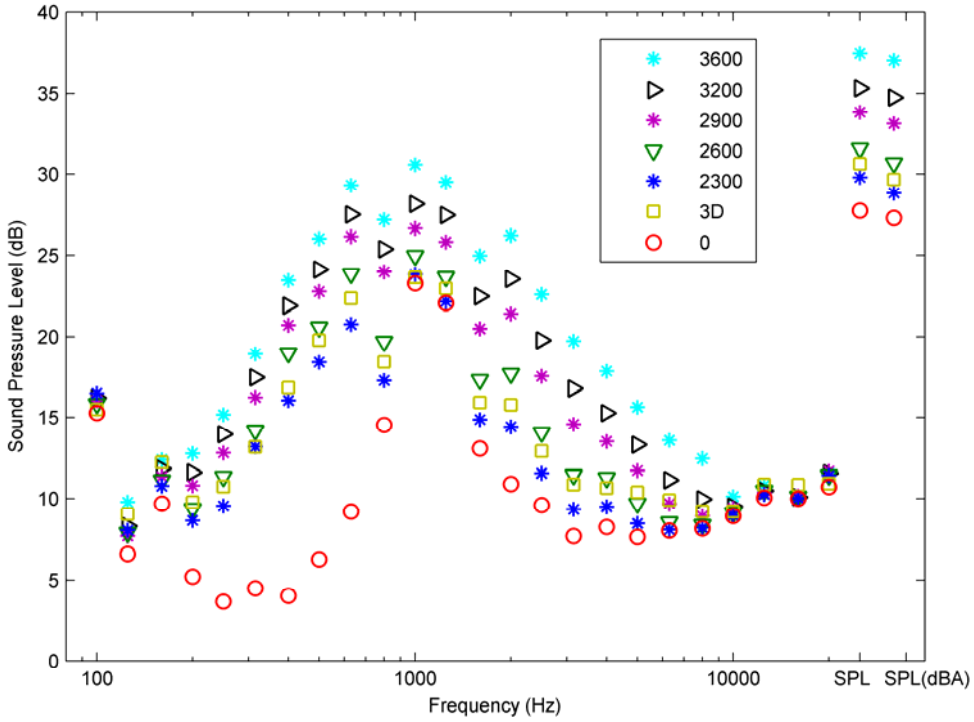

Figure 4: Noise measurement of F41 laptop under standard desk test.

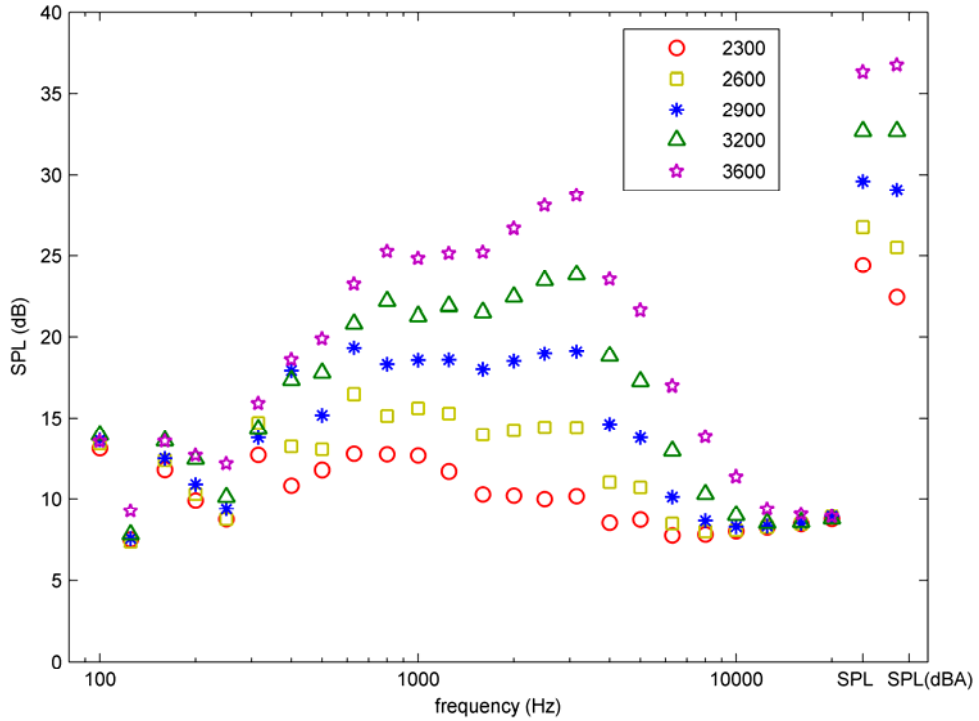

Figure 5: Noise measurement of F41 fan under standard desk test.

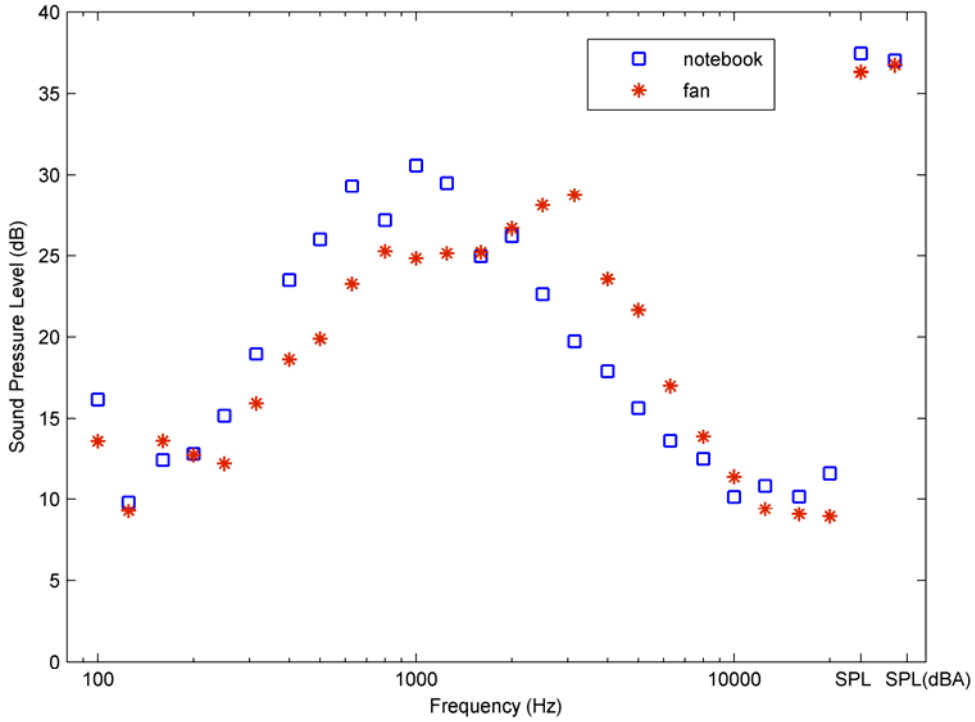

Figure 6: Noise measurement of F41 fan and F41 laptop with fan speed of 3600 rpm under standard desk test.

3.2 Experimental Results of F21 Laptop

Similar to the F41 laptop, the spectrum profiles of the F21 laptop are very similar and not sensitive to the fan speed, Fig.7. But unlike F41 laptop, the noise energy of F21 laptop mainly stays in the frequency band between 800 Hz and 3000 Hz and reaches maximum near 1600 Hz. As explained in 3.1, the noise peak nearby 1600Hz is caused by the cavity resonance of the F21 laptop. The size of the F21 laptop is smaller than the F41 laptop, and thereby a higher cavity resonance could be expected. When rotation speed of the fan reaches 5800 rpm, the sound pressure level of the laptop exceeds 40 dB.

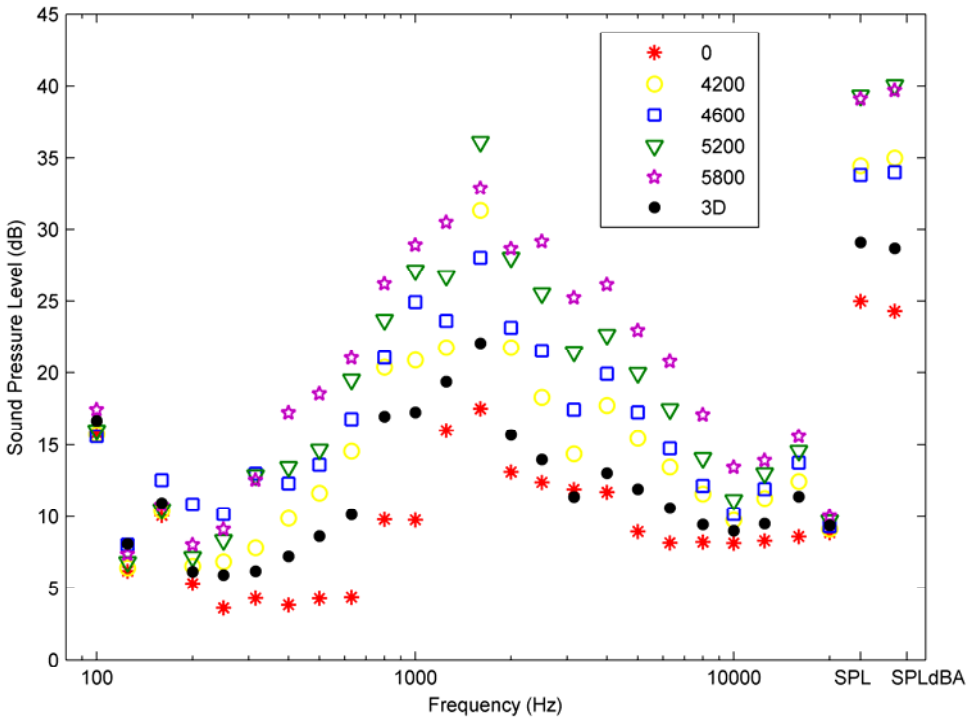

Figure 7: Noise measurement of F21 laptop under standard desk test.

The noise spectra an unattached F21 fan varied with fan speed are given in Fig.6. Again, it is obvious that the noise spectra of unattached F21 fan are rather different with that of F21 laptop. The noise energy of the unattached F21 fan mainly stays in the frequency band between 800 Hz and 8000 Hz and reaches maximum near 5000Hz. Furthermore, the spectrum profiles of the unattached F21 fan are varied with the fan speed, since the major noise band become narrower with the increase of the fan speed. When rotation speed reaches 5800 rpm, the sound pressure level of the unattached fan exceeds 40 dB.

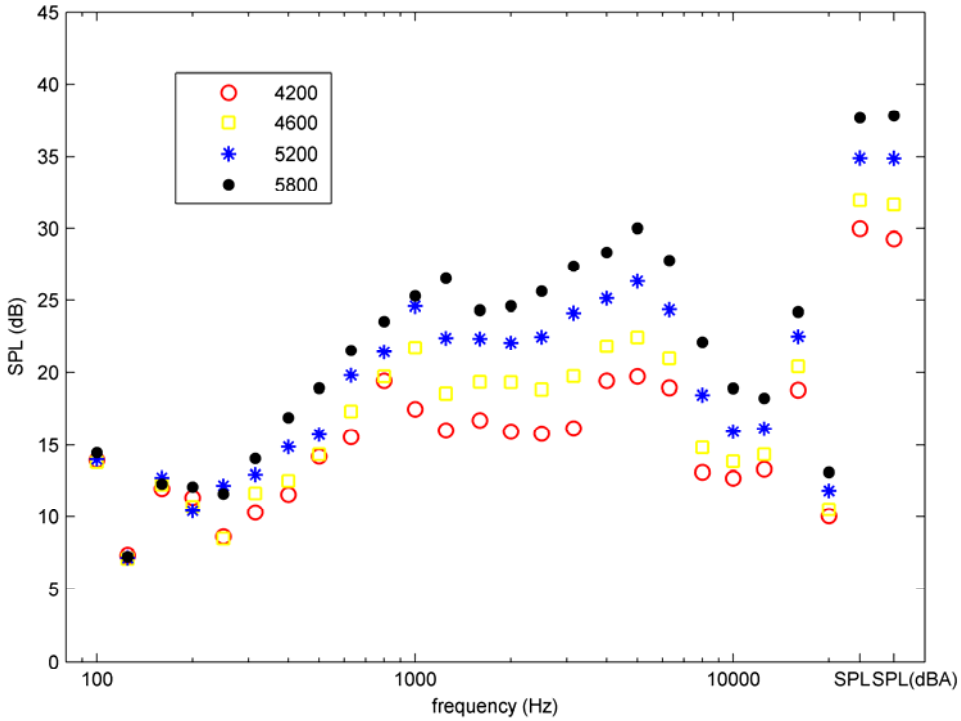

Figure 8: Noise measurement of F21 fan under standard desk test.

Comparing the noise spectra of the F21 laptop with that of the unattached F21 fan at the same speed, Fig.9 reveals that the laptop structure has significant influence on the noise radiation. The laptop structure successfully reduces the noise radiation of the unattached fan above 4000Hz and has almost no influence on the noise radiation below 600Hz. For the frequencies between 700Hz and 3000Hz, the laptop structure increases the noise radiation of the unattached fan significantly. Around the frequency of 1600 Hz, the laptop structure magnifies the noise radiation to a maximum value.

Similar to the F41 laptop, the reason that the laptop structure increases the noise radiation remarkably around 1600Hz is caused by the structure cavity inside the laptop. If absorption material is applied to the interior cavity artificially, the noise levers nearby 1600Hz can be sufficiently reduced. This implies that acoustic design for the laptop structure could play a key role on avoiding the cavity resonance.

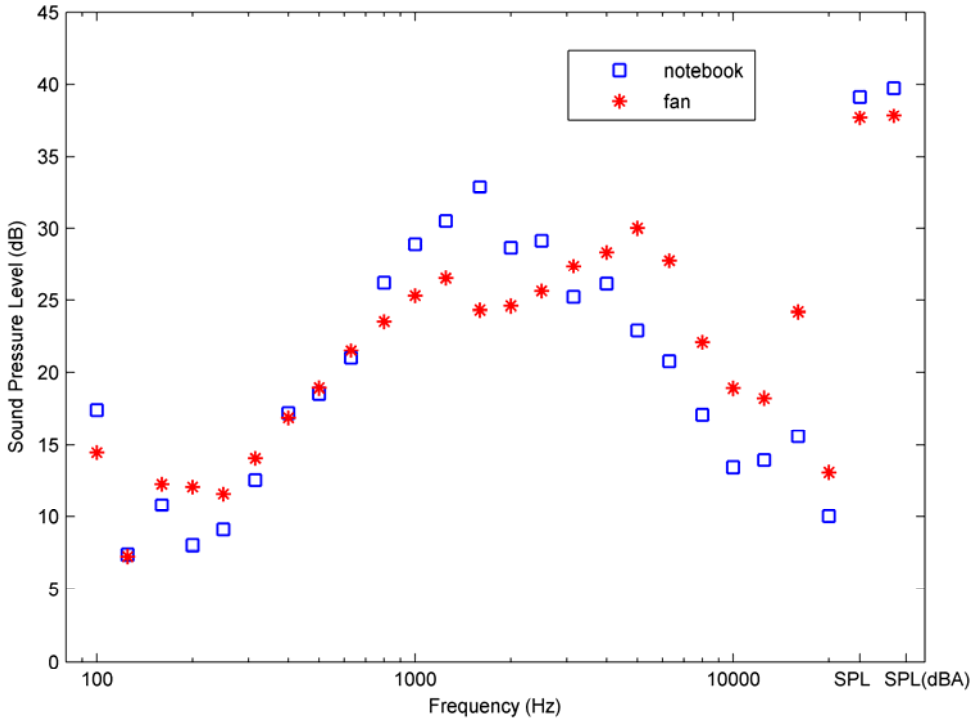

Figure 9: Noise measurement of F21 fan and F21 laptop with fan speed of 5800 rpm under standard desk test.

4 CONCLUSIONS

Comprehensive testing of F41 and F21 laptops and their relevant fans has been conducted to provide a better understanding of the laptop's noise radiation behavior. The standard desk testing gives a criterion to compare noise radiation of Lenovo laptops with that of the unattached fans. The measured data indicated that the structure of the laptop plays an important role on the noise radiation of the laptop. The laptop structure significantly increases noise radiation in the middle frequency range due to acoustical resonance of interior cavity of the laptop. For F41 laptop, the noise is amplified around 1000 Hz, and for F21 laptop, the noise is strengthened around 1600 Hz. These noise amplifications in the middle frequency range are sensitive to the absorptive material artificially added to the interior cavity of the laptop.

5 REFERENCES

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