Research Articles

EXPERIMENTAL STUDY ON NOISE MAPPING OF SPLIT UNIT AIR CONDITIONER SYSTEM

by : M.S.M.Sani and M.H.A. Rasid

Abstract

This paper presents the procedures and the results of noise source at the split unit air conditioner system. Noise in split unit air conditioning system is a frequent problem for the air conditioner manufacturers. Split unit air conditioners have an indoor unit and an outdoor unit connected by communication pipes. Noise can reduce the efficiency and performance of the air conditioner. In order to identify and analysis of noise at air conditioner system, experiment has been conducted using sound intensity mapping method.

The investigation is carried out by varying the parameter which is the fan speed and temperature at air conditioner. In order to identify where the noise source comes from, a grid rig had been build to get the noise location and their rating by located the microphone at the rig point. The signal from the probe will be analyze by using Pulse LabShop software.

The results from the noise were showed in noise mapping with different color which indicates the different level of noises from different location. The highest noise sound levels occur at the front side of air conditioner which is at the fan that is about 74.784dB. The second highest noise sound level is occur at the right side which is at the compressor about 72.115dB. It can be concluded that sound power level will increase as higher as fan speed at the lowest temperature of the air conditioner.

Keywords: Sound Intensity Mapping, Noise Source, Fan Speed, Temperature, Pulse LabShop

Noise in split unit air conditioning system is a frequent problem for the air conditioner manufacturers. Split unit air conditioners have an indoor unit and an outdoor unit connected by communication pipes. Noise can reduce the efficiency and performance of the air conditioner.

Introduction

Air conditioners are typically categorised into split-type and multi-type air conditioners. Split-type air conditioners have an indoor unit and an outdoor unit connected by communication pipes. Multi-type air conditioners have plural indoor units connected to an outdoor unit. Air conditioners may also be categorised into ones that air conditioners operate a refrigerant cycle in one direction to only supply a room with cool air, and ones that selectively operate a refrigerant cycle in two directions to supply a room with hot or cool air. Now days, mostly every home has their own air conditioner system is to provide comfort during hot days and nights.

A frequent problem for the air conditioner manufacturer is the noise comes from the air conditioner. The noise is considered undesirable and the cause of the noise may in some cases even limit the heating or cooling efficiency of the air conditioner.

The noise produced by air conditioning unit probably caused by several mechanical and aerodynamics sources such vibration of the compressor shell, electric motor vibration and fan noise [1]. Any mechanical coupling of such source as the fans, the compressor or the electric motor will cause the cabinet panel to vibrate and radiate acoustics energy.

The most annoying source of noise at some air-conditioning units appears to be due to the vibration of the electric motors at 120 Hz and harmonics [1,2]. Actually this vibration is due to fluctuations in the magnetic forces [2]. There are some studies on the fan noise have found that it involved experiment with minor geometry changes of fan to reduce noise. Morinushi [3] have reported that minor changes in the location can have minimal effects on fan performance.

This is parallel with Graham [4] stated that fan performance and efficiency are normally negatively affected by such changes. Field survey of the disturbance caused by the noise of outdoors residential air conditioner units [5]. Leventhall and Wise [6] reviewed the design specifications especially for low frequency noise and discussed the dominants factors in noise complaints.

Noise mapping from air conditioned noise in classroom have been discussed by Lilly [7]. Research on the basic acoustical measurement methods based on sound pressure measurement to determine the sound power radiated from fans [8]. Basically, prediction of dominant noise source is very important in machinery noise control problem [9].

There are several standards for sound intensity measurements completed or under progress. ISO 9614 governs sound power determinations based on sound intensity [10-12]. This standard divided into two parts, one use for point measurements (ISO 9614-1) and another one makes use for scanned measurements (ISO 9614-2).

However ISO 9614-2 is the most popular method and can be used for engineering and survey grade determination of sound power. Furthermore, ISO 9614 has been extended to allow scanned measurements to be for precision grade determination of sound power (ISO 9614-3).

In this research, noise source identification of split unit air-conditioner system was determined by experimental approach. Simple test rig have been fabricated to ensure the noise location by doing the experiments.

Result and Discussion

Noise generated from air conditioner systems was measured from different views to find out the noise contribution. Sound power is a measure of the amount of sound energy a sound source produces per unit time, independent of its surroundings. Sound power has a number of useful applications.

It can be used to calculate the approximate sound pressure level at a given distance from a machine operating in a specified environment. It can be compare the noise radiated by machine of the same or different type. In this section, different temperature and fan speed were used to identify where the noise source of the air conditioner system always occurs. It easy to determine the source depends on the colour that obtain from the mapping process.

The noise level indicator will present the value depends on the colour of the measurements. Table 1 shows that high 20^{0}C will produce the highest value of sound power level at critical point foremost at all sides compare to the other different temperature. An even show that at the front side shows the increments of sound power level but for the other sides it present that the highest value still at high 20^{0}C.

The a-weighted one-third band sound power levels radiated by different parts of the units were determined from sound intensity measurements made on different parts of the air conditioner and for different temperatures and different speeds of the fan.

TABLE 1 : SOUND POWER LEVEL AT CRITICAL POINT FOR DIFFERENT TEMPERATURES

	Sound Power Level (dB)		
Sides \ Parameter	High at 20°C	High at 22°C	High at 24°C
Front	74.7	75.682	75.683
Back	66.275	64.272	65.926
Right	72.115	67.617	70.345
Left	59.409	56.967	58.348

Figure 1 presents that the peak frequency occurred at 160Hz and the measurements will pick at this frequency. Figure 2 shows a-weighted one-third band sound power levels for the sound radiated form high speed of fan and temperature 20oC at a front side. Table 2 shows the details value of noise level at different location to determine where the highest sound signal radiated from the air conditioner. The sound power radiated of about 74.789 dB.

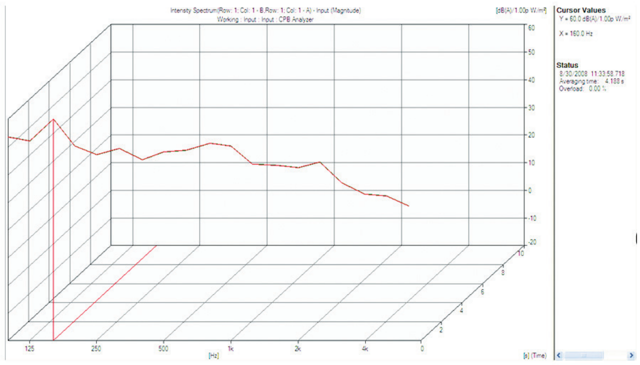

Figure 1
Frequency for front side is at 160Hz for 20°C

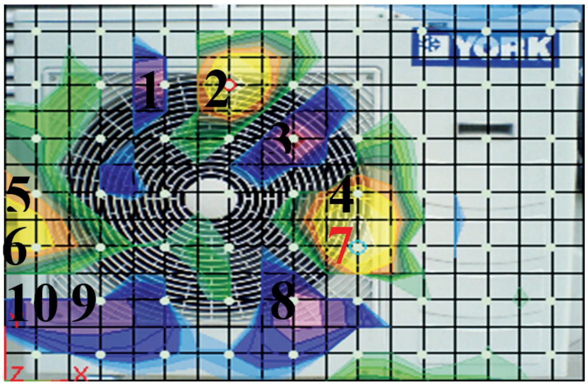

Figure 2
Noise sources for high speed fan at 20°C
at the front side

TABLE 2 : SOUND POWER LEVEL AT THE CRITICAL POINT AT THE FRONT SIDE FOR 20°C			
Location	Noise level, dB	Location	Noise level, dB
1	71.163	6	71.51
2	74.678	7	74.789
3	71.812	8	71.105
4	71.572	9	67.798
5	68.718	10	69.212

Figure 3 and 4 show the peak frequency and a-weighted one-third band sound power levels result for the back side of the air conditioning unit. Table 3 shows the details value of noise level at different location to determine where the highest sound signal radiated from the air conditioner. The sound power level obtain is about 66.278dB at the highest peak of frequency is 630Hz. From the observation, the noise come forms the vibration of the housing of the air conditioner with the floor.

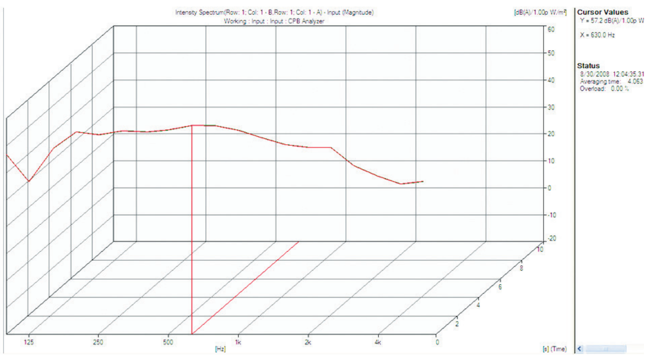

Figure 3
Frequency for back side is at 630Hz for 20°C

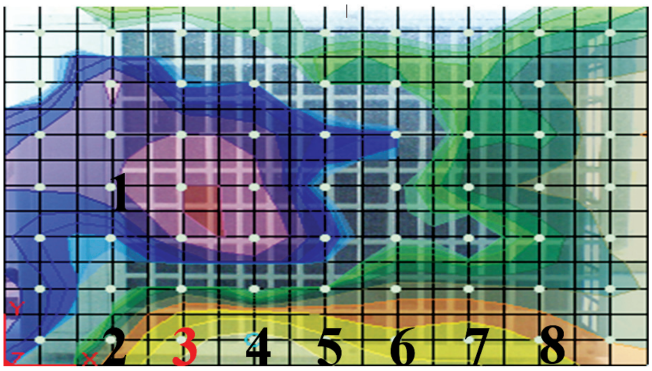

Figure 4
Noise sources for high speed fan at 20°C
at the back side

TABLE 3 : SOUND POWER LEVEL AT THE CRITICAL POINT AT THE BACK SIDE 20°C			
Location	Noise level, dB	Location	Noise level, dB
1	62.51	5	62.947
2	64.87	6	62.375
3	66.278	7	62.339
4	64.37	8	62.225

The noise radiated at 160Hz for the right side of the air conditioner system as shown in Figure 5. Figure 6 shows the a-weighted one-third band sound power levels radiated from right side where is behind the compressor and the total sound power levels is around 72.115dB. Table 4 shows the details value of noise level at different location to determine where the highest sound signal radiated from the air conditioner. The total sound power levels increased about 5dB from the back side. This shows that the noise at the compressor radiated more at the right side.

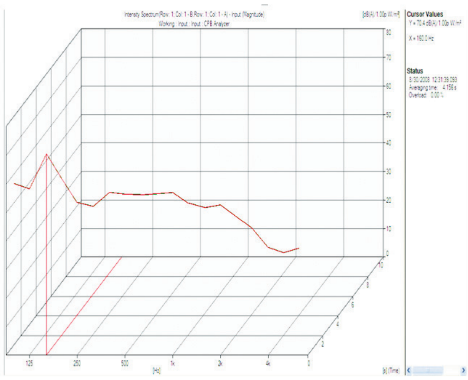

Figure 5
Frequency for right side is at 160Hz for 20°C

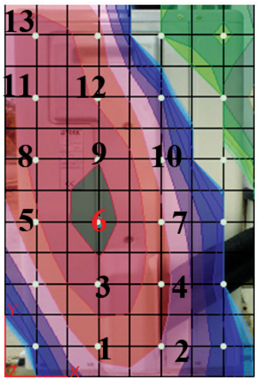

Figure 6
Noise sources for high speed fan at 20°C
at the right side

TABLE 4 : SOUND POWER LEVEL AT THE CRITICAL POINT AT THE RIGHT SIDE FOR 20°C			
Location	Noise level, dB	Location	Noise level, dB
1	69.226	7	68.741
2	68.448	8	71.448
3	69.198	9	70.284
4	70.876	10	71.048
5	69.817	11	69.698
6	72.115	12	70.385

The noise radiated at 160Hz for the left side of the air conditioner system as shown in Figure 7. Figure 8 presents result for the a-weighted one-third band sound power levels from left side where is close to the fan. Table 5 shows the details value of noise level at different location to determine where the highest sound signal radiated from the air conditioner. Form the noise mapping it gives 59.409dB at 160Hz for the total sound power levels. The sound power levels are low compare to the front side because the noise from the fan radiated more from the front side.

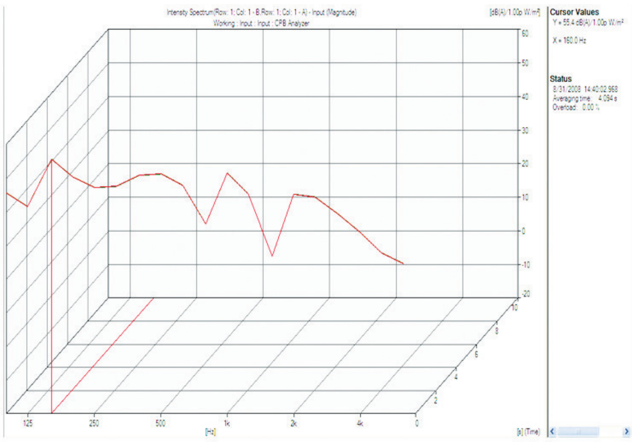

Figure 7
Frequency for left side is at 160Hz for 20°°C

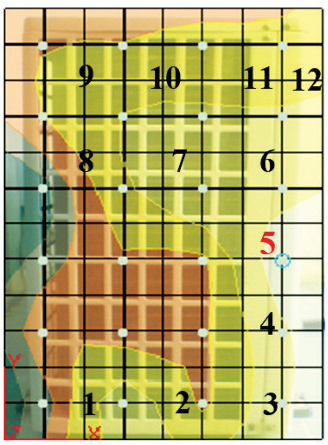

Figure 8
Noise sources for high speed fan at 20°C
at the left side

TABLE 5 : SOUND POWER LEVEL AT THE CRITICAL POINT AT THE LEFT SIDE FOR 20°C			
Location	Noise level, dB	Location	Noise level, dB
1	57.902	7	57.193
2	655.204	8	56.762
3	58.341	9	57.051
4	58.28	10	57.24
5	59.409	11	57.178
6	57.848	12	57.075

Figure 9 shows the total sound power at different temperature and the fan speed is constant at high fan speed. It was measured at all average for each side to see that where the noise radiated more. Figure 10 shows the total sound power at different temperature and the fan speed is constant at medium fan speed. It was measured at all average for each side to see that where the noise radiated more. Figure 11 shows the total sound power at different temperature and the fan speed is constant at medium fan speed.

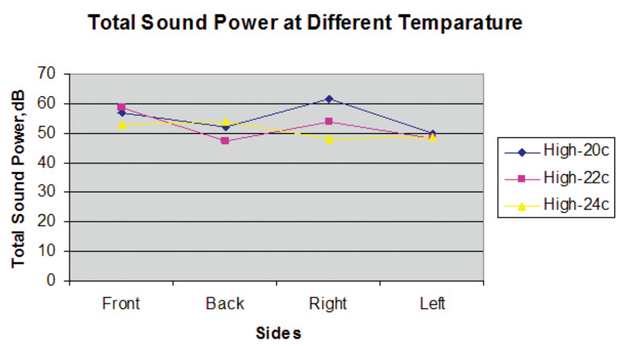

Figure 9
Graph of total sound power at different temperature for high fan speeds

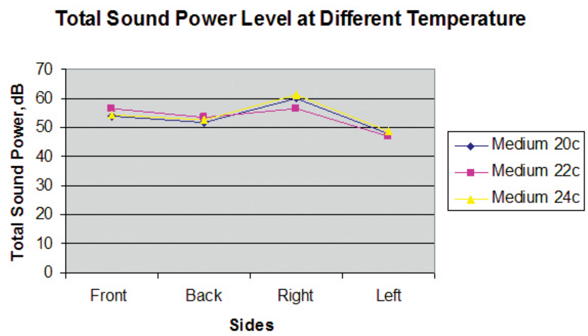

Figure 10
Graph of total sound power at different temperature for medium fan speeds

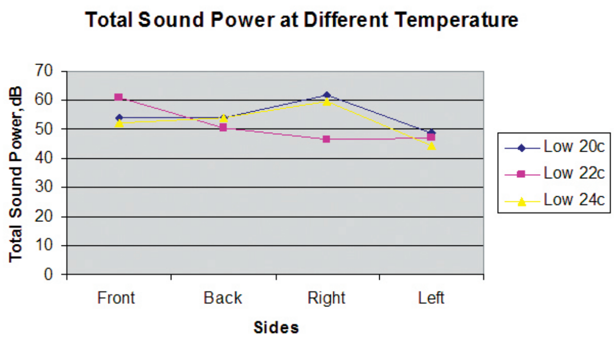

Figure 11
Graph of total sound power at different temperature for low fan speeds

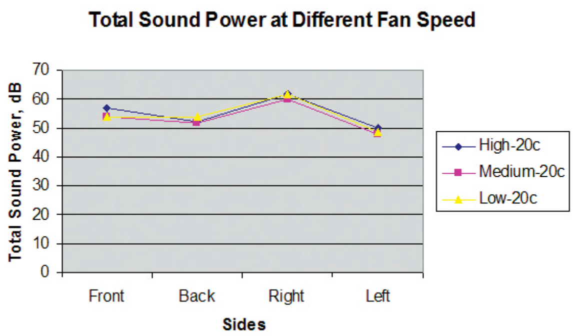

Figure 12
Graph of total sound power at different fan speeds at 20°C

However, the purpose of this section is to find out the effect of fan speed at the same temperature. Figure 12 shows the total sound power for different fan speeds at 20°C. It was measured at all average for each side to see where the noise radiated more and the effect to sound power at different fan speeds. Figure 13 shows the total sound power at different fan speeds at 22°C. Figure 14 shows the total sound power at different fan speeds at 24°C. It was measured at all average for each side to see that where the noise radiated more.

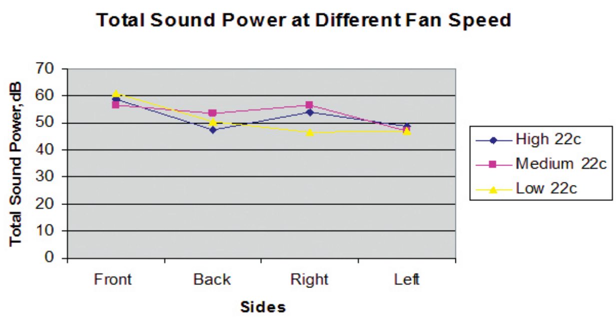

Figure 13
Graph of total sound power at different fan speeds at 22°C

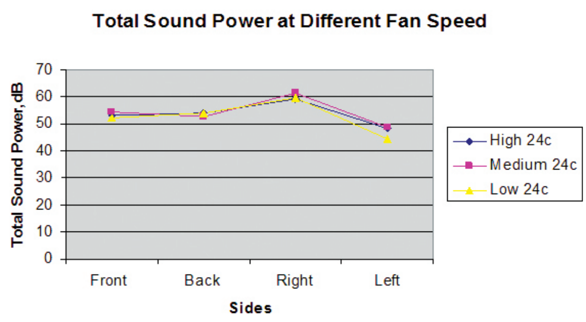

Figure 14
Graph of total sound power at different fan speeds at 24°C

Conclusion

The result obtained from the sound intensity mapping process shows that for different temperature and different fan speed gives different effect on the noise signal as had been proved in this project. Sound power level will increase as higher fan speed and the lowest temperature of the air conditioner.

From the analysis of the data it can be concluded that the highest noise sound levels occur at the front side which is at the fan that is about 74.784 dB. The second highest noise sound level is occur at the right side which is at the compressor is about 72.115 dB.

The results that get from the analysis give the similar result with two papers that shows the noise generated from the air conditioner systems always occurred at the fan and compressor.

REFERENCES

[1] M.J.Crocker, J.P. Arena, R.E. Dyamannavar (2004), "Identification of noise on a residential split-system air conditioner using sound intensity measurements", Journal of Applied Acoustics 65:2004, pp 545-558.

[2] A.F.Seybert, M.J. Crocker, J.W. Moore, S.R.Jones (1973), "Reducing the noise of a residential air conditioner", Noise Control Engineering Journal 1973:1(2), pp 79-85.

[3] K.Morinushi (1987), "Influence of geometric parameters on centrifugal fan noise", Journal Vibration Acoustics 1987:109(3), pp 227-234.

[4] J.B. Graham (1991), "Handbook of acoustical measurements and noise control", New York - McGraw Hill, Chapter 41.

[5] J.S. Bradely (1993), "Disturbance caused by residential air conditioning noise", Journal Acoustics Society American 1993:93(4): pp1978-1986.

[6] H.G. Laventhall, S.S. Wise (2000), "Making noise comfortable for people", Journal American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Trans, pp 896-900.

[7] J.G. Lilly (2000), "Noise in classroom", Journal American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Trans 2000:4295), pp 21-29

[8] W. Neise (1995), "Sound power measurement procedures for fans", ACTA Acoustics Journal 1995:3(5), pp 473-485

[9] M.J. Crocker (1998), "Generation of noise in machinery, its control and the identification of noise source", Handbook of Acoustics, New York: Wiley, Chapter 66.

[10] ISO 9614-1. Acoustics - determination of sound power levels of noise sources using sound intensity - Part 1: Measurement at discrete points. International Organization for Standardization;1993.

[11] ISO 9614-2. Acoustics - determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning. International Organization for Standardization; 1996.

[12] ISO 9614-3. Acoustics - determination of sound power levels of noise sources using sound intensity -Part 1: Precision method for measurement by scanning. International Organization for Standardization; 2002.