NOISE SOURCE IDENTIFICATION OF SPLIT UNIT AIR CONDITIONER SYSTEM

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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To my beloved Father and Mother

Abd Rasid Bin Haji Ayub
Habshah Binti Abu Hassan

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All praises and thanks be to Allah S.W.T, who has guided us to this, never could we have found guidance, were it not that Allah had guided us! (Q7:43)

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ABSTRACT

Noise in split unit air conditioning system is a frequent problem for the air conditioner manufactures. Split unit air conditioners have an indoor unit and an outdoor unit connected by communication pipes. The noise can not be eliminated but it can be reduced. Noise can make in some cases limit the cooling efficiency of the air conditioner. In this project, to identify and analysis the noise at air conditioner system was investigated by using sound intensity. The investigation was carried out by varying the parameter which is the fan speed and temperature at air conditioner. For the identify where the noise source comes form the 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 the analyzer using Pulse LabShop software from Brüel & Kjær. The results for the noise were showed in noise mapping. A different colour in the noise mapping indicates different level of noise and it showed where the most noise comes from. 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 is about 72.115dB. Comparison of the graph will show the relation between noise and the parameter and it can be concluded that sound power level will increase as higher fan speed and the lowest temperature of the air conditioner.

ABSTRAK

Bunyi bising di dalam sistem pengahawa dingin jenis unit berasingan kerap kali meninbulkan masalah kepada pengusaha penghawa dingin. Unit berasingan ini terdiri daripada unit dalam dan unit luar yang disambung menggunakan paip. Bunyi bising yang dihasilkan tidak boleh dihapuskan tetapi boleh dikurangkan. Dalam beberapa perkara bunyi bising boleh mengurangkan kecekapan penghawa dingin tersebut. Di dalam projek ini, cara keamatan bunyi digunakan untuk mengenal pasti dan menganalisis bunyi bising di dalam sistem penghawa dingin. Kajian telah dijalankan dengan mempelbagaikan pembolehubah seperti halaju kipas dan suhu pada sistem penghawa dingin. Untuk mengenal pasti dari mana datangnya sumber bunyi bising itu jaring telah dibina untuk mendapatkan lokasi serta kadar bunyi bising tersebut dengan meletakkan mikrofon pada bahagian jaring itu. Signal daripada penguji tersebut akan dianalisis oleh analyzer menggunakan perisian Pulse LabShop dari Brüel & Kjær. Hasil bunyi bising itu ditunjukkan di dalam pemetaan bunyi bising. Warna yang berbeza daripada pemetaan menunjukkan kadar bunyi bising yang berbeza dan menunjukkan di mana sumber bunyi yang paling bising. Bunyi yang paling bising berlaku pada bahagian depan iaitu kipas lebih kurang 74.784dB. Bunyi yang kedua paling bising berlaku pada bahagian kanan iaitu pemampat lebih kurang 72.115dB. Perbezaan grah menunjukkan hubungan di antara bunyi bising dengan pembolehubah tersebut dan ini boleh disimpulkan bahawa aras kuasa bunyi akan bertambah dengan penambahan kelajuan kipas dan penurunan suhu penghawa dingin.

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$p(t)$	Instantaneous sound pressures
$v_r(t)$	Particle velocity in the direction of r
t	Time
ω	Natural Frequency
$\triangle r$	The separation distance between the two microphones
$G_{12}(\omega)$	The one-sided cross-power spectrum density function between microphone channels1 and 2
ρ	Density
$I_r(\omega)$	Sound Intensity

LIST OF ABBREVIATIONS

hp	Horsepower
HVAC&R	Heating, ventilating, air conditioner and refrigerating
BLDC	Brushless DC motor
CFD	Computational Fluids Dynamics
CAE	Computer Aided Engineering
NVH	Noise, vibration, and harshness
FEM	Finite Element Methods
MIG	Metal Inert Gas

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Air conditioners are typically categorized 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 categorized 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. Usually, split unit air conditioner system is commonly being use in more appliances.

A frequent problem for the air conditioner manufacture is the noise comes from the air conditioner. 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. Noise level can not be eliminated but it can be reduce.

As the customer's requirements for more silent operation of appliances is increasing, reducing of the noise levels in air-conditioner is concentrated. An air-conditioning system of low noise level is especially welcomed as the most important aspect of installing it is to provide a comfortable environment for leisure, relaxation and sleeping.

1.2 PROBLEM STATEMENTS

Live in comfort ness in their house is a dream of everyone. Consumers prefer a low noise air conditioner to make sure that unwanted noise did not disturb them. So, for the comfort ness reduces of the noise levels that occur from the air conditioner is necessary.

1.3 OBJECTIVES

Basically, the objectives of this project are listed below:

a) To identify noise source in split unit air conditioner system using sound intensity measurements.
b) To analysis the noise in split unit air conditioner system at different parameter.

1.4 SCOPES OF PROJECT

This research focus on identify noise source that happen in split unit air conditioner system using sound intensity measurements. The focus areas on this project are:

a) Focuses on split unit air conditioner system with 1horsepower (hp).
b) Sound intensity mapping to measure the noise produces from the air conditioner using Pulse LabShop software.

1.5 OUTLINE

This project present identifying the noise location and rating level of noise in the split unit air conditioner system. This report consist 5 chapter contain background of the project as well as the details information that clarify overall of project.

Chapter 1 is the introduction part for this project. On this chapter, the general description of the problem is defined. This chapter consists of the objectives of this project, the problem statements and the scope of study as well as the background of this project.

Chapter 2 presents the literature review on the final year project. This project is reviewed through from journal, books and technical note that are related to this project to make this final project clearer.

Chapter 3 contains the flow chart and project methodology of this final year project which shows how the project is carried on from the start until the end.

Chapter 4 covers the preliminary finding that is obtained from previous research through the journal, books and technical note that suitable for the final year project. The finding includes the result and discussion on the research that can be compared with the result obtained from final year project.

Chapter 5 is the last chapter where overall project is concluded.

1.6 GANTT CHARTS

The Gantt chart shows all the project activities from week one until week fourth teen. Start with define the title until go for presentation. The Gantt chart will be attaching at the appendix A.

CHAPTER 2

LITERATURE REVIEW

2.1 AIR CONDITIONER

Air conditioner is a combined process that performs many functions simultaneously. It conditions the air, transports it, and introduces it to the conditioned space. It provides heating and cooling from its central plant or rooftop units. It also controls and maintains the temperature, humidity, air movement, air cleanliness, sound level, and pressure differential in a space within predetermined limit for the comfort and health of the occupants of the conditioned space or for the propose of product processing.

The term HVAC&R is an abbreviation heating, ventilating, air conditioner and refrigerating. The combination of process in this commonly adopted term is equivalent to the current definition of air conditioner. Because of all these individual components processes were developed prior to the more complete concept of air conditioning, the term of HVAC&R is of used by the industry. [1]

2.2 AIR CONDITIONER SYSTEM

An air conditioning or HVAC&R, systems is composed of components and equipments arranged in sequence to conditioned space and control the indoor environmental parameters of a specific space within required limits.

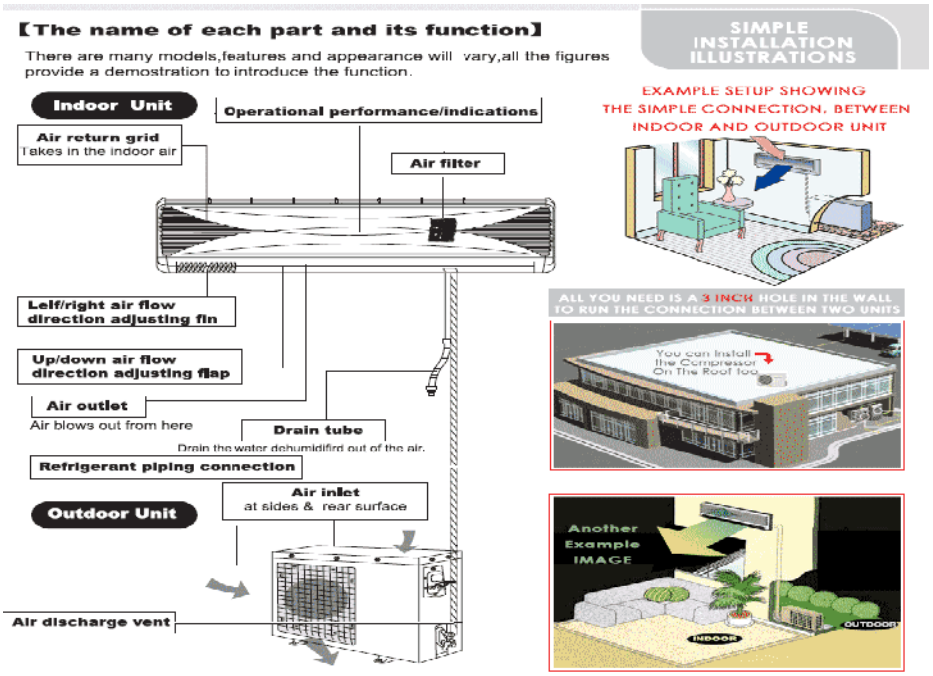

Figure 2.1 Split Unit Air Conditioner Systems
Source: Handbook of air conditioner and refrigeration

Most of air conditioning systems perform the following functions:

a) Provide the cooling and heating energy required.

b) Condition the supply air, that is, heat or cool, humidity or dehumidify, clean or purify, and attenuate any objectionable noise produce by the HVAC&R equipment.

c) Distributed the conditioned air, containing sufficient outdoor air, to the conditioned space.

d) Control and maintain the indoor environmental parameters – such as temperature, humidity, cleanliness, air movements, sound level, and pressure differential between the conditioned space and surroundings – within predetermined limits.

Parameters such as the size and the occupancy of the conditioned space, the indoor environmental parameter to be controlled, the quality and the effectiveness of control and the cost involved determine the various types and arrangements of components used to provide appropriate characteristic. [1]

2.3 NOISE

Sounds are unpleasant or unwanted are called noise. Noise problem are commonly happen in split unit air conditioner system. The noise produced by an air conditioning and heating unit may be caused by several mechanical and aerodynamic sources:

a) Vibration of the compressor shell.
b) Electric motor vibration.
c) Fan noise. [2]

Noise is a very important performance of a split-unit air condition which consists of indoor set and outdoor set. The noise generated by an air conditioner outdoor set consists of three parts:

a) The aerodynamic noise.
b) The high frequency noise generated by the compressor.
c) The low frequency vibrating noise. [3]

2.4 SOUND INTENSITY

Noise is an unavoidable part of everyday life and technological development has resulted in an increase in noise level from machines, factories and traffic. Noise that produce from air conditioner system can causes annoyance and hearing damage. It is therefore important that steps towards a reduction in noise are taken, so that noise is not something that had to accept.

In order to reduce noise, the amount and location of noise have to be identifying by using sound intensity mapping. Sound intensity is defined as the rate of energy flow through a unit area. When locating the source of sound, sound intensity is very useful because it is a vector unit that gives the magnitude and direction. [4]

2.5 SOUND INTENSITY INSTRUMENTS AND TECHNIQUES

Sound intensity probe consists of two closely pressure microphones which measure both sound pressure and pressure gradients between the microphones. The signal processing necessary convert these signals to sound intensity values is carried out in the sound intensity analyzer. The microphone selection has to fulfill two rather different groups of conditioned:

a) It must be operate satisfactorily over a range of environmental condition such as humidity, temperature, air pollution and wind.
b) It must also meet technical constraints such as frequency response, dynamic range, directivity and stability.

The ability of the sound intensity technique to reject background noise from other machinery operating in proximity to the machine of interest is specially advantages for this analysis. [5]

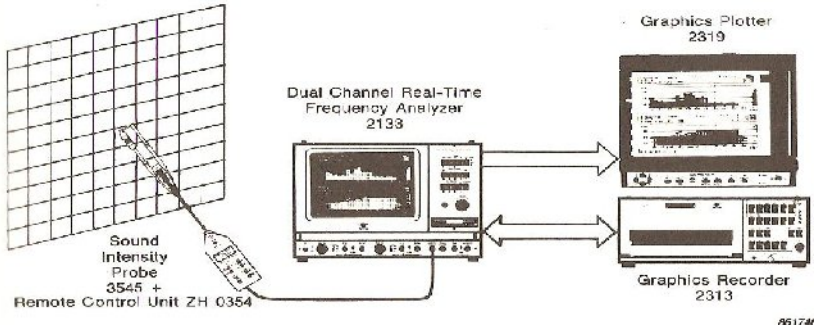

Figure 2.2 Instrumentation used for sound intensity measurements with a schematic representation of a measurement grid.
Source: Brüel & Kjær

2.6 SOUND FIELDS

The sound energy will not always be allowed to radiate freely from the source. When sound radiated in a room reaches the surfaces some energy will be reflected and some will be absorbed by, and transmitted through the surfaces. In a room with hard reflecting surfaces, all the energy will be reflected and a so called diffuse field with sound energy uniformly distributed throughout the room is set up. Such a room is called a reverberation room. In a room with highly absorbent surfaces all the energy will be absorbed by the surfaces and the noise energy in the room will spread away from the source as if the source was in a free field. Such a room is called an anechoic room.

In practice, the majority of sound measurements are made in rooms that are neither anechoic nor reverberant but somewhere in between. This makes it difficult to find the correct measuring positions where the noise emission from a given source must be measured. It is normal practice to divide the area around a noise source:

a) Near field

   The area very close to the machine where the sound pressure level may vary significantly with a small change in position. The area extends to a distance less than the wavelength of the lowest frequency emitted from the machine, or at less than twice the greatest dimension of the machine, whichever distance is the greater. Sound pressure measurements in this region should be avoided.

b) Far field

   Divided into the free field and the reverberant field.

c) Free field

   The sound behaves as if in open air without reflecting surfaces to interfere with its propagation. This means, that in this region the sound level drops 6 dB for a doubling in distance from the source.

d) Reverberant field.

Reflections from walls and other objects may be just as strong as the direct sound from the machine. [4]

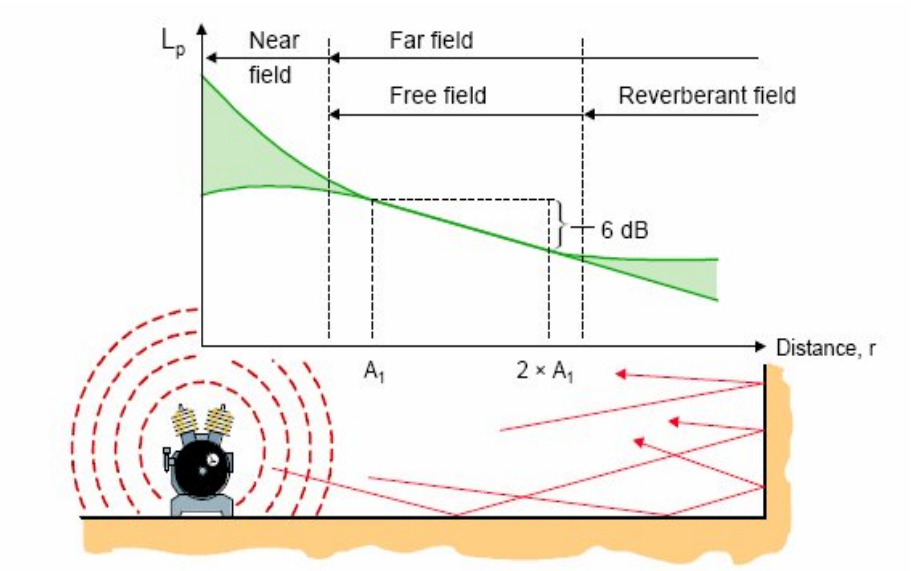

Figure 2.3 Shows details on sound fields
Source: Brüel & Kjær

2.7 PAPER REVIEW

Cogging torque from Brushless DC (BLDC) motor is an undesirable effect that prevents the smooth rotation of the rotor and results in noise. This paper identifies the source of excessive noise in the small fan-motor system for household refrigerators. The source is presumed to a mechanical resonance excited by torque ripple of the BLDC motor. By using finite element analysis, natural frequencies and mode shapes of the rotating part of the system are obtained and they are compared with experimental mode shapes obtained by electronic torsional excitation test which uses BLDC motor itself as an exciter. Measurement of noise and vibration was conducted in an anechoic room. An accelerometer (B&K4371) was set on the top of the motor and a microphone (LA5110, Onno-Sokki) was set 0.50m apart from the fan motor at the same height. A four-channel FFT analyzer (Medallion 2300, Zonic) was used for data acquisition and signal processing. [6]

Sound intensity at a point in a sound field in a specific direction r can be expressed as:

$$I_r = \frac{1}{T}\int_0^T p(t)v_r(t)dt \quad (1)$$

where T is a sufficiently long averaging time, *p(t)* and are instantaneous sound pressures, $v_r(t)$ and particle velocity in the direction of r. The tests were carried out in an anechoic room, which has acoustic wedges on all surfaces except the floor, which is of smooth concrete. The sound pressure at the midpoint of the two microphones can be obtained by taking the arithmetic average of two sound pressure signals:

$$P(t) = \frac{P_1(t) + P_2(t)}{2} \quad (2)$$

The particle velocity at that midpoint can be obtained by Euler's equation for a zero-mean velocity medium:

$$V_r = -\frac{1}{\rho}\int \nabla p(t)dt \approx -\frac{P_2(t) - P_1(t)}{j\omega\rho\nabla r} \quad (3)$$

By using Fourier transforms, sound intensity can also be expressed as

$$I_r(\omega) = \frac{\mathrm{Im}\{G_{12}(\omega)\}}{\rho\omega\nabla r} \quad (4)$$

The measurements were made with a two-microphone sound intensity probe and these resulted in sound power level data. The sound power levels produced by radiation from the inlet, exhaust and cabinet were obtained for five different volume flow rates. Some studies on fan noise have found that it is of little use to experiment with minor changes in geometry or configuration of the fan itself in an attempt to reduce noise. This is because fan performance and efficiency are normally adversely affected by such changes.