An Introduction to Measuring PC Noise

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Why should PC noise be measured?

Personal computers have become a significant and widespread source of noise in modern workplaces, schools and homes. Noise pollution is one of the major forms of environmental degradation in the modern world. Noise has been linked to obvious ailments such as hearing loss, but also affects productivity and concentration in workers, creates unnecessary stress among all users, and impinges on leisure and recreation around PCs. Identifying the acoustic contribution of each PC is a start to better management of noise in human environments.

Does PC noise pose any danger to health?

In large numbers PCs may produce enough noise to cause hearing damage over time. However, direct hearing damage is rarely caused by PC noise. Stress is a primary health risk, and noise is a contributor to stress. Even in small numbers and at relatively low acoustical levels, the noise produced by PCs can increase stress and in doing so, increase health risk factors. The World Health Organization recommends a maximum ambient noise floor of 35 dBA for comfortable speech intelligibility and annoyance avoidance in classrooms and in homes.

How loud are most PCs?

Most production PCs range in noise from a low of about 2.5 bel to a high of over 5.0 bel. There are very few PCs at the quiet end of the range. A PC rated for 3.0 bels or lower can generally be considered very quiet. A PC that measures 4.0 bels or higher would be regarded by most people as loud.

What are bels and decibels?

A bel is a primary measuring unit for sound volume, named after Alexander Graham Bell, the inventor of the telephone and an early modern acoustician. A decibel (dB) is derived from the combination of deci and bel; it means one-tenth of a bel. Both bel and decibel can be used to describe Sound Pressure Level (SPL) or Sound Power. It has become standard practice in recent years, however, to use bel for sound power and decibel for SPL in order to avoid confusion.

What is Sound Pressure Level?

When a mass vibrates in air, it creates disturbances of the ambient atmospheric pressure. The oscillating variations in sound pressure creates a sound wave. Sound Pressure Level (SPL) is a relative quantity: it is the ratio between the actual sound pressure and a fixed reference pressure, defined as the threshold of hearing, or 0 decibels -- .0002 dynes/cm2.

Given a fixed sound source, SPL may vary in accordance with frequency and will diminish with distance. The measured SPL varies with angle, position and acoustical environment, so a single SPL measurement in not a reliable indicator of the overall noise emitted by a source. An SPL measurement is like a single snapshot photograph. It cannot show the whole acoustic picture.

What is Sound Power?

Sound Power is a measure of the total acoustic energy emitted by a noise source. Sound power is measured in watts or picowatts, and sound power levels are expressed in bels where 0 bels corresponds to 1 picowatt. Sound power is essentially independent of the measuring environment and can be described as an intrinsic property of the noise source.

Consider sound power akin to a 3-D image compiled from many photographs. It involves multiple microphone measurements from many positions around the sound source. Unlike SPL measurements, it is not dependent on environmental factors. Sound power is a more accurate measurement of noise under a wide range of environments,

A sound level meter in an anechoic chamber

and correlates better with human perception, especially for comparative purposes.

What equipment is needed to measure PC noise?

The minimum tools needed are:

- An accurate calibrated sound level meter (SLM)
- A quiet room in which the ambient noise is lower than the noise source by ~6 dB
- CPU, hard drive, and/or system stress/benchmark programs

An SLM measures sound pressure level (SPL) in decibels (dB). The device should have the facility to measure flat frequency response or apply the "A" frequency response weighting curve.

This equipment is enough to perform sound power measurements, but only if you have the considerable acoustics knowledge needed to conduct the correct SPL samplings and make the calculations to convert the SPL measurements into sound power. Standard 1 meter SPL readings will be no problem, however.

What is the "A" frequency response weighting curve?

Human hearing is not linear. We hear middle frequencies best, and we are less sensitive to lower and higher frequency extremes, particularly at lower loudness levels. These tendencies were charted, and an inverse frequency response curve was created to compensate for typical human hearing deviation from flat frequency response. That is the "A" weighting curve. Measurements that have this weighting applied are denoted dB(A) or bel(A). (In PC sound power measurements, the A weighting is almost always applied, so just bel is commonly used.)

How sensitive does the SLM have to be?

It depends on how much or how little noise the test PC makes. The most broadly accepted standards for noise measurement use a 1 meter measuring distance between test object and microphone. Such a distance places high demands on microphone sensitivity and on the signal-to-noise ratio of the preamp circuits when the noise source is low in level. If it is one of the quietest PCs, an SLM capable of measuring accurately down to 20 dB (or even lower) is ideal, but such highly sensitive devices are expensive.

One workaround to the 1 meter measuring distance requirement is to measure at 0.5 meter. Because of the way sound decays over distance, if the measuring environment is a full anechoic chamber and the noise source is positioned in the center of the chamber, the difference in measured SPL between the 0.5 meter and 1 meter distances should be 6 dB. (In a normal room, it is more complex to work out, and may have to be verified experimentally, but the difference should be 3 dB.)

If the SLM does not register any increase in noise even at 0.5 meter, then a more sensitive SLM or a quieter room is needed. If the PC is easily heard when it is turned on but the SLM does not register

An anechoic chamber used for sound power readings

Photo Courtesy of SilentPCReview

RTA screen showning spectrum analysis of entire audio frequency band

any change, then most likely, a more sensitive meter is needed.

How quiet does the room have to be?

Again, it depends on how much or how little noise the test PC makes. Ideally, it should be 6 dB quieter than the noise source. Anechoic chambers are usually quiet enough to measure 2.5 bel noise sources. It is possible to get ambient noise levels down to ~25 dBA on a quiet night in a detached house in a quiet residential neighborhood, with equipment such a refrigerators and furnaces turned completely off.

What is an anechoic chamber?

It is a room that is designed to have no acoustic reflections. The word anechoic comes from the combination of the prefix an meaning without, and echo: no echo. The room is usually constructed with very solid walls, ceiling and floor, sometimes on a "floating" room-in-a-room construction to minimize noise transmission via mechanical coupling. To eliminate acoustic reflections, triangular wedges of fiberglass or other sound absorbent material are affixed to all the inner surfaces, including the floor, in a full anechoic chamber. While they are echo-free, anechoic chambers are rarely 100% noise proof, and most have lower ambient noise levels at night.

The full anechoic chamber usually employs a wire mesh suspension so as not to damage the absorbent material on the floor. Hemi-anechoic chambers, which are acoustically treated on all inner surfaces except the floor, have become more prevalent in recent years due to the ease of working within them.

The reason anechoic chambers are useful for acoustic measurements is because the absence of echoes means that there is no reinforcement, cancellation or other interaction between the primary sound source and the reflections of that primary sound off the walls, ceiling and floor. It is similar to measuring outdoors -- but without the pervasive influence of wind that affects outdoor acoustic measurements.

When compared to SPL measurements in a normal room, SPL measurements at the same distance in an anechoic chamber are almost always lower in level. The actual difference will vary significantly on the particular sound, and on the acoustical properties of the particular room.

What is a reasonably simple way to get useful noise measurements of a PC with a SLM in an anechoic chamber?

If sound power testing can be conducted, by all means do so. It is far superior to simple SPL measurements. However, sound power measurements are not considered by most people to be simple, and so are not covered in this document.

1. Check and calibrate the SLM.
2. Ensure that the SLM has enough sensitivity to read at least several dBA below the rated noise level of the PC.
3. Pick as quiet a time as possible.
4. Set up the PC in the middle of the chamber, away from the walls and other objects, either on a non-resonant table just big enough to hold all the components, including the monitor, or on the floor.
5. Measure and record the ambient noise of the chamber with no other noise sources in the room. Make sure the SLM is reading in dB(A). Make note of the effects of any extraneous noises such as stomach gurgling and wait till they pass to record the noise reading.
6. For best results, mount the SLM or its microphone on a shock-mounted stand.
7. Now turn on the PC, allow it to boot fully, and when the system is idling, take a measurement 1 meter away from the center of the PC front bezel.

8. Take measurements at the chosen distance from the back, and the sides of the PC as well. If possible, take a measurement 1 meter above the PC.
9. Run a hard drive benchmark that forces the hard drive in the PC to go into seek mode for some time, and repeat the above measurements.
10. Run a system or CPU stress program for 10~30 minutes that will increase internal temperatures and force any thermally controlled fans in the power supply, on the CPU heatsink or other components, and check the noise again. If there appears to be a change, record the noise measurements again.
11. Play a CD/DVD in the optical drive and repeat the noise measurements.

The end result will be SPL noise data for the system in idle, with the hard drive in seek, at maximum load, and finally with the optical drive engaged. The above steps should be repeated in exactly the same way when conducting noise measurements on another PC so that the data is comparable apples-to-apples.

What is a reasonably simple way to get useful noise measurements of a PC using a good but modest SLM in a quiet but ordinary room?

This methodology is far less accurate and repeatable than the one above involving an anechoic chamber due to the inherent lack of control over acoustics. It is also difficult to find a normal room with an ambient noise level of less than 25~30 dBA.

1. Check and calibrate the SLM if at all possible.
2. Pick as quiet a time as possible.
3. A carpeted room is generally preferable to one that is not.
4. Set up the PC in the middle of the room, away from the walls and other objects, preferably on a non-resonant table just big enough to hold all the components, including the monitor.
5. Measure and record the ambient noise of the room near the system with no other noise sources in the room. Make sure the SLM is reading in dB(A). Make note of the effects of any extraneous noises such as stomach gurgling and wait till they pass to record the noise reading.
6. For best results, mount the SLM or its microphone on a shock-mounted stand.
7. Now turn on the PC, allow it to boot fully, and when the system is idling stably, take a measurement 1 meter away from the center of the PC front bezel.
8. If the SLM does not register any change in noise compared to when the PC was off, then decrease the distance to 0.5M. If it is still not registering any increase in noise, then you need a more sensitive SLM or a quieter room. If you can easily hear the PC when it is turned on but the SLM does not register any change, then most likely, a more sensitive meter is needed.
9. Take measurements at the chosen distance from the back, and the sides of the PC as well. If possible, take a measurement 1/0.5 meter above the PC.
10. Run a hard drive benchmark that forces the hard drive in the PC to go into seek mode for some time, and repeat the above measurements.
11. Run a system or CPU stress program for 10~30 minutes that will increase internal temperatures and force any thermally controlled fans in the power supply, on the CPU heatsink or other components, and check the noise again. If there appears to be a change, record the noise measurements again.
12. Play a CD/DVD in the optical drive and repeat the noise measurements.

Photo Courtesy of SilentPCReview

Sophisticated realtime analyzer capable of spectrum analysis down to below 0 dBA used for professional acoustic measurements

The end result will be SPL noise data for the system in idle, with the hard drive in seek, at maximum load, and finally with the optical drive engaged. The above steps should be repeated in exactly the same way when conducting noise measurements on another PC so that the data is comparable apples-to-apples.

When reporting noise measurements, what information should be included?

For simple SPL measurements, the dBA value @ distance and the point of reception (by the SLM microphone) should be provided. The operational state of the PC during the noise measurement should be specified as well. An example:

25 dBA @ 1M distance from center of front bezel of PC case with system at idle

Information about the equipment used, the ambient noise of the testing room, details about the room itself (including internal dimensions, furnishing, etc), and the placement of the measured equipment in that room are all factors that have a bearing on the outcome, and so should be included.

For sound power measurements, all the relevant declaration information is covered by the standards ISO 7779 and ISO 9296