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SOUND MASKING APPLICATION GUIDE

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Sound Masking Application Guide

What is Sound Masking?

The amount (or the process) by which the threshold of audibility for one sound is raised by the presence of another (masking) sound. Specifically, it is a distributed sound system that delivers a shaped spectrum amplified pink noise in sufficient levels to mask other peoples conversations and low level background noises.

It is used most often in open office plans where cubicle walls do not extend to the ceiling and a need for conversational privacy is desired. It should be noted that under proper conditions, a sound masking system can provide relief from unwanted noises and conversations, however, complete confidential privacy will usually require floor to ceiling walls.

Pink Noise

Random noise having equal energy within each octave of the audio spectrum. The level decreases at a rate of 3 dB per octave. Used for testing and equalization of sound systems.

White Noise

Random noise having equal energy at all frequencies. Used for testing.

Objectives

1. The goal of this application guide is to demystify of the elements of sound masking while providing a plain “how to” type of approach for installing a sound masking system. We will discuss the steps from the design process through installation and troubleshooting.

2. The intent of this guide is not to provide theory on sound masking. Listed in the references are books and papers that cover sound masking theory, and we highly recommend reading them. If you are new to the business of commercial sound, you should probably have one of the books for reference.

Getting Started

This guide assumes the reader will have a basic understanding of the equipment used in a simple distributed sound system. Some of the components the reader should be familiar with:

70 volt distribution amplifier

Equalizer

8 ohm loudspeakers with 70 volt line transformers

Noise generator

1/3 octave Real Time Analyzer

A high quality digital voltmeter (True RMS reading) and or an oscilloscope

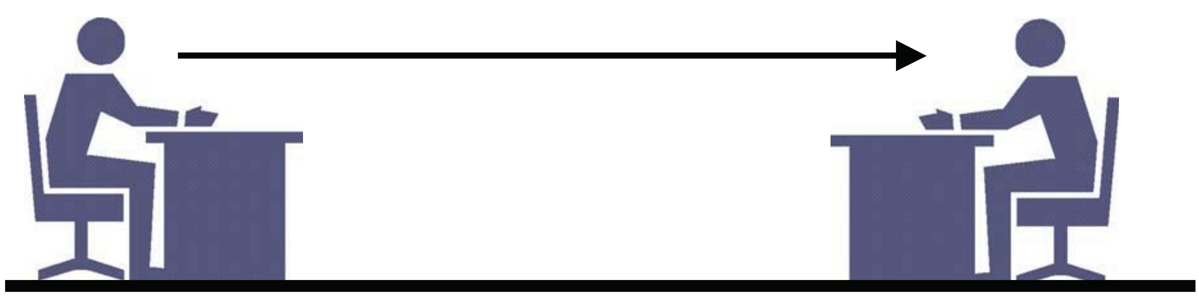
Ideally you should use a noise generator that has an equalizer built in and is made specifically for sound masking. This will be covered in more detail later.

Sound Masking Overview

Most sound masking speakers are installed above a drop ceiling. They are typically hung in the airspace or airspace/plenum ceiling and aimed upward. The sound reflects off the ceiling first and by the time it enters the room below it has dispersed in a very wide pattern and covers the room at an even volume. If the airspace/plenum ceiling is made of a non-reflective or sound absorbing material the speakers can be aimed sideways; or if the airspace/plenum area has adequate height, the speakers should be mounted as high as possible and aimed downward. In cases where there is very little space above a drop ceiling, or no drop ceiling at all, the speakers may be aimed downward similar to a paging/background music system. This particular method will work much better if the ceiling is 10 feet or more in height. If the ceiling is lower than that, hot spots may occur which could call too much attention to the sound masking system and become offensive to the occupants. If there is no drop ceiling and the ceiling is high, the speakers should be hung from the ceiling and aimed upward.

Other factors of equal importance are the acoustics of the room. The walls, ceilings and floors have the ability to either reflect or absorb sound. To decrease the level of sound one receives from other areas, the sound must be attenuated. In figure 1 you can see that with no walls the only attenuation between coworkers is the distance between them. Each time you double the distance, you drop 6 dB in sound level (inverse square law). Occupants within a completely open office would have to be so far apart for the noise level to be reduced it would not be practical. It would not be reasonable to use sound masking in this situation because the sound masking level would have to exceed 50 dB to be effective. Most experts agree that sound masking levels above 45dB are too irritating for any length of time.

Attenuation = 6dB/ distance doubled



Source

Receiver

Figure 1

In figure 2 you see a typical movable wall that is 5’ high that separates two co-workers. The wall provides about 10dB of attenuation, depending on the fabric and the material inside. This helps reduce the direct sound (line A) somewhat, but some sound still diffracts over the wall (line B) and some sound reflects off the ceiling (line C). The sound that encounters the wall and migrates around is called diffracted sound. It is affected most by the height of the wall. The ceiling height, and especially its ability to absorb sound, are very important. Even if the ceiling is made up of acoustic tiles, care must be taken where hard reflective surfaces like light fixtures are installed. If a light fixture with a hard plastic cover were installed between the two cubicles, the reflected sound would have minimal attenuation. Carpeted floors and heavy padding are recommended.

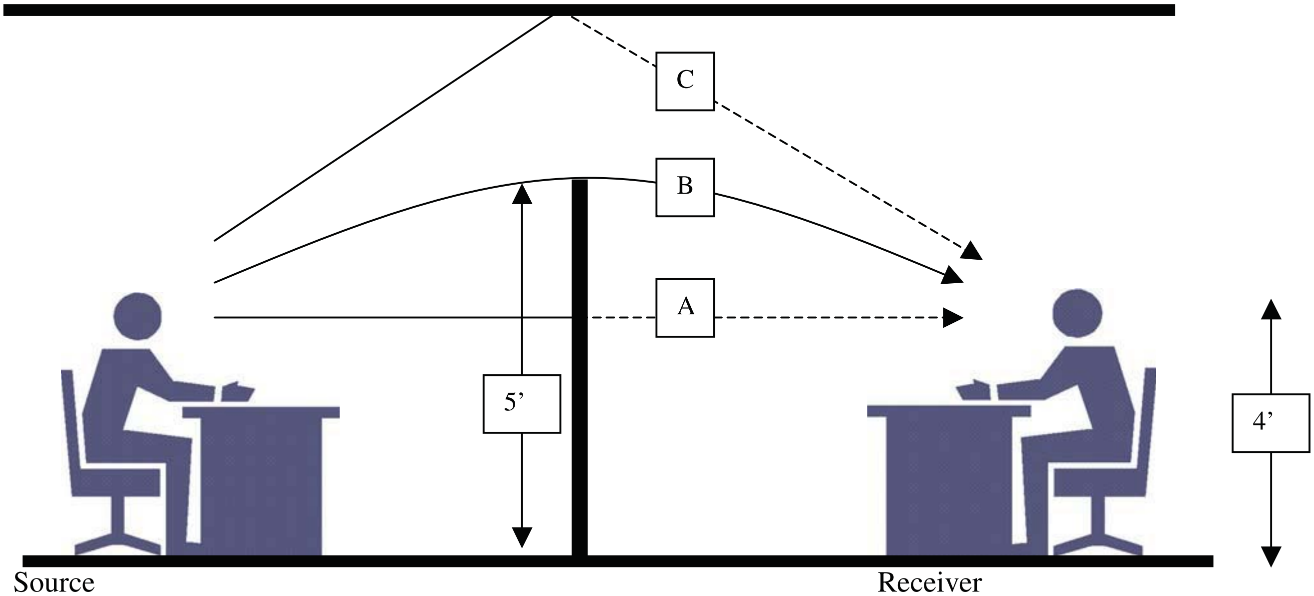


Figure 2

Note:

Please be aware that while it is our goal to provide as much information as possible in this guide, there are criteria that can only be determined for each individual installation. Some of the items that have to be considered on a per job basis are:

- Height of the ceiling and type of ceiling material
- Height of the airspace/plenum area
- Wall and floor materials used
- Sound measurement method and equipment used
- Sound masking system equipment used
- Ambient noise levels in room
- Direct and reflected sounds between work areas

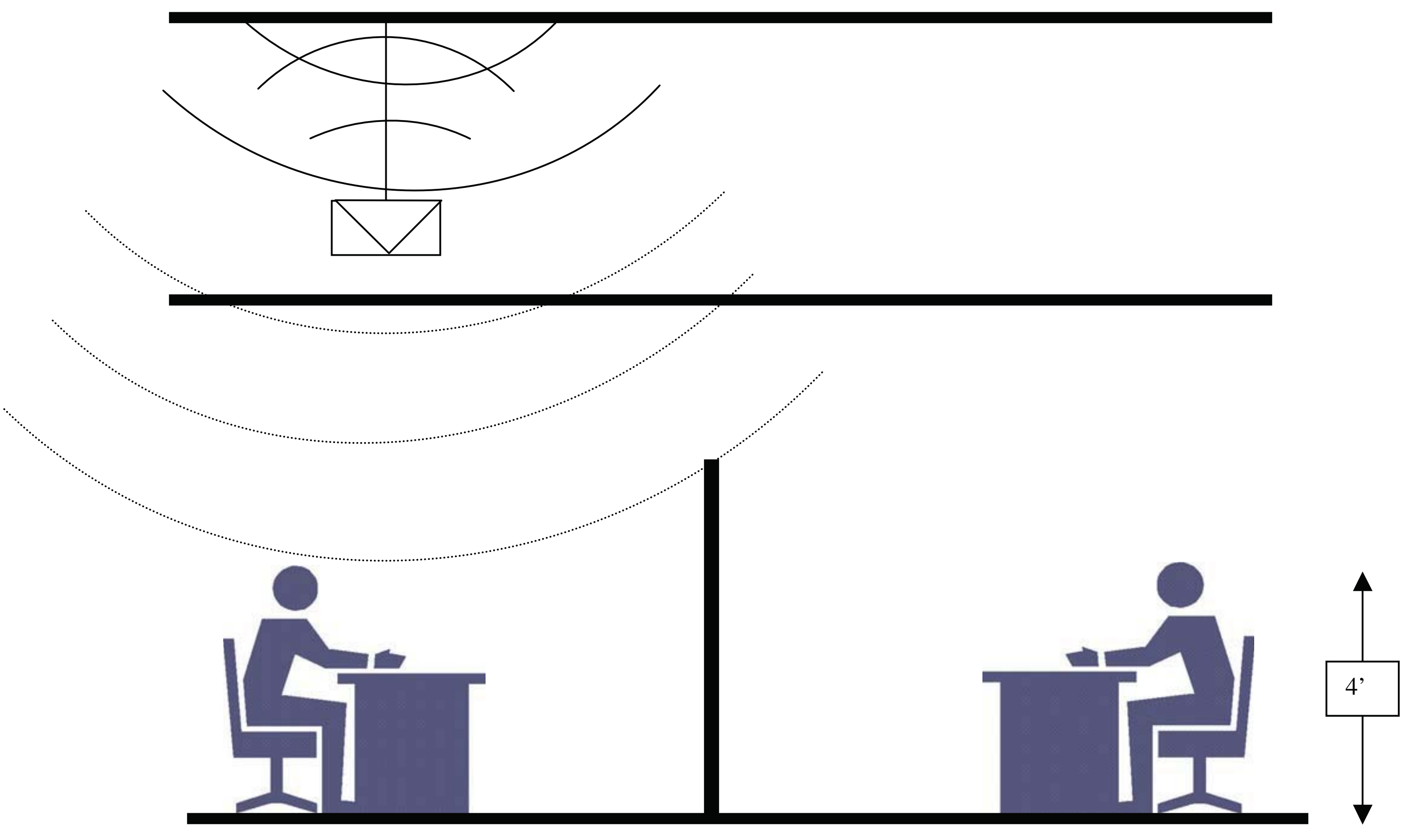
- Typical Layout

Airspace/plenum Ceilings

Typically, speakers are placed on 10 - 20 foot centers in a square or hexagonal array and hung from the upper deck of the airspace/plenum aimed upward. Ideally there will be 3-4 feet of airspace/plenum space above the drop ceiling. Speakers are hung from chains and are suspended approximately 8 inches above the drop ceiling. This allows the speaker to radiate upward and reflect off the upper deck back down to and through the drop ceiling (figure 3). Under these ideal conditions, 14-foot centers are acceptable. The speakers are typically tapped at 1 watt and individual volume controls will give you even more precise control. The individual volume controls are a must for the speakers in transition zones.

When the airspace/plenum area or the upper deck has absorbent material you will have to place the speakers on closer centers. When the airspace/plenum area is very large (5 feet or more) you will have to use more power to cover the increased volume. This could result in using higher taps on the speaker and a larger amplifier.

Figure 3



Open Ceiling

With open ceiling installations the speaker should hang 2-4 feet from the ceiling and be fired upward. A critical issue for consideration is the ceiling height. The higher the ceiling, the wider the spacing of the speakers, and higher taps and additional power may be required.

! If the ceiling height (not tall enough) prohibits upward firing, the speakers should be mounted firing downward. In this application the speaker spacing should be closer together, and they should be tapped lower to avoid hot spots. The dispersion of the speakers and the layout become a primary consideration. Too much overlap will potentially cause hot spots, and too much space between speakers will potentially cause dead spots. If the ceiling is less than 10 feet, a letter could be written to the owner/architect explaining the performance limitations of the system.

Choosing the equipment

Amplifier

With full spectrum noise running continuously the amplifier should be oversized, for a couple of reasons. When an amplifier is running 24 hours a day it never gets a chance to cool down, and if the amp outputs full power continuously, it may not last. When using shaped pink noise you will have spikes that are above the average level which can cause clipping and distortion. A good rule of thumb is to allow 50% headroom when selecting the amplifier.

In addition to providing an amplifier with plenty of headroom, amp durability is a must. If the amp fails during the day, the building occupants will notice the sudden change. In this instance, the system may have to be “ramped up” again upon startup to avoid complaints. It might be sensible to have an auxiliary amplifier that turns on if the primary amp fails.

Another method is to use 3 amplifiers and 3 pink noise sources. Each will receive one of the three amplified noise sources so that no two adjacent speakers will have the same source. The idea is to provide a more random noise throughout the facility. This method also provides an automatic backup if one of the amplifiers fail.

Noise Generator & Equalizer

The most common and convenient way of providing noise and equalization for this application is to install a single unit designed specifically for masking applications. Many companies offer pink noise generators with a built in equalizer. It is usually easier if one is chosen with a computer interface for programming and minimal controls on the unit itself. You don’t want anyone to be able to change any of the settings. The unit should feature a method for increasing the volume a small amount every day until it reaches the required level for that environment. (ramping up) This allows the building occupants to gradually become accustomed to the sound over a period of time making the sound less obtrusive. Another feature to be aware of is adequate control of the low frequencies. A good equalizer will go down to 31.5 Hz. Many experts believe that the sound masking noise is more acceptable when it is provided below 200 Hz. A summary of the recommended features:

- 1/3 octave equalizer or better with built in sound masking generator

- High and low pass filters
- Non volatile memory for storing levels and filters
- Frequency response and control from 31.5 Hz to 16 kHz
- No front panel controls for anyone to tamper with
- Serial computer interface
- Ability to step up the volume in small increments (.5 - 1 dB over a period of time)

Speaker Assembly

Speaker

The speakers should have a frequency response of 65 Hz to 16 kHz. A quality paging speaker should be capable of this. A paging speaker with better low frequency response would be ideal. A four inch speaker has a wider dispersion angle although the trade off is that it is usually less efficient than an eight inch speaker.

Backbox

The backbox should be available in large and small volumes and it should be very well sealed. For optimum performance you would want:

- A large volume box for better low frequency response.
- A tightly sealed and acoustically dampened box for better performance and less extraneous noise.

Volume Control

A volume control is useful for making individual output level controls. In addition, if there is only one amplifier for all your speakers and the level has to be changed at any speaker, the transformer taps won't have to be re-wired. The volume control is especially important for transition areas where a lower level is required.

Baffle

The baffle should include a dust screen to prevent debris falling onto the speaker cone. Since the speaker is aimed upward in most cases over time a foreign object could fall from the ceiling, through the baffle holes onto the speaker and make a rattling noise.

Mounting

Look for a masking speaker assembly that provides universal mounting. It should be capable of upward, downward and side firing. It should come with a suspension chain for mounting to the ceiling airspace/plenum.

Noise Measurements

Understanding, measuring and amplifying noise is the essence of sound masking. Each room will have it's own ambient noise level. It will also have different noise levels at different frequencies and the levels will vary as the air handling equipment cycles on and off. Initial ambient noise measurements should be taken with air handling equipment operating, so as to provide a good reference range. Choose the upper end of this range as your ambient noise reference level. Plot this out on log paper with the horizontal (X) axis representing frequency and the vertical (Y) axis

representing signal amplitude in dB. It will look something like figure 4 below.

Figure 5

Ambient room noise measurement done with TEF 20 Analyzer.

SPL measurements with a Real Time Analyzer

It is assumed that some type of Real Time Analyzer (RTA) will be used for measuring SPL at 10 or more frequencies from 31.5 Hz to 16 kHz. All measurements in this guide are made in a flat response mode.

A weighted curve

A simulation of what the human ear hears at levels below 55 dB. This curve has a low frequency roll off starting at 1 kHz and down to –40dB at 30 Hz.

C weighted curve

A simulation of what the human ear hears at levels from 85 to 140dB. The curve has slight high and low frequency roll off.

Flat

Flat response with no weighting applied to the level reading at all. We have used this method throughout this guide for accuracy and simplicity. Some people use the A weighted curve for sound masking because it is a low level. This is okay, but the levels recommended in this guide should be converted to A weighted levels.

Speeds

For sound masking slow or medium speeds are probably the easiest to read.

Ambient Noise

Establishing your ambient noise level is a very important first step in setting up the sound masking system. This is because 20-25 dB is needed above ambient noise, for speech to be understood. When the sound masking is turned on, the ambient noise will increase and you will need to know what level to set it at to achieve the desired 20-25 dB window for speech intelligibility. A normal conversation at 3 feet will be about 70 dB. This means that you would not want to let your sound masking level to exceed 45-50 dB at 1 kHz. Most experts agree that 45 dB is the highest level that can be tolerated. The ultimate goal is to raise the ambient/ masking noise level so two people 1-3 feet apart can have a normal conversation but if they try to carry on a conversation from one cubicle to another, it will be unintelligible. More accurate methods of determining the effectiveness of the masking system can be used. If you contact ASTM (see References) they have standards for this. The sound masking curve will be shaped like the ambient noise curve above, except shifted upward.

Typical Office Noise

The typical office noise measured will vary based on the level of activity occurring at that time. You could also have variation in level as the air handling system cycles on and off. As you can see in figure 4 above, two measurements were made at different times of the day and we have a slight variation in level.

Sound Masking Noise

The thick black line in figure 6 below is your target level and slope for the sound masking noise setting. In this case the masking noise when added to the room will have to be amplified by varying amounts across the spectrum shown below. Let the amplifier do the majority of the amplification and use the equalizer to cut frequencies that exceed the target masking level.

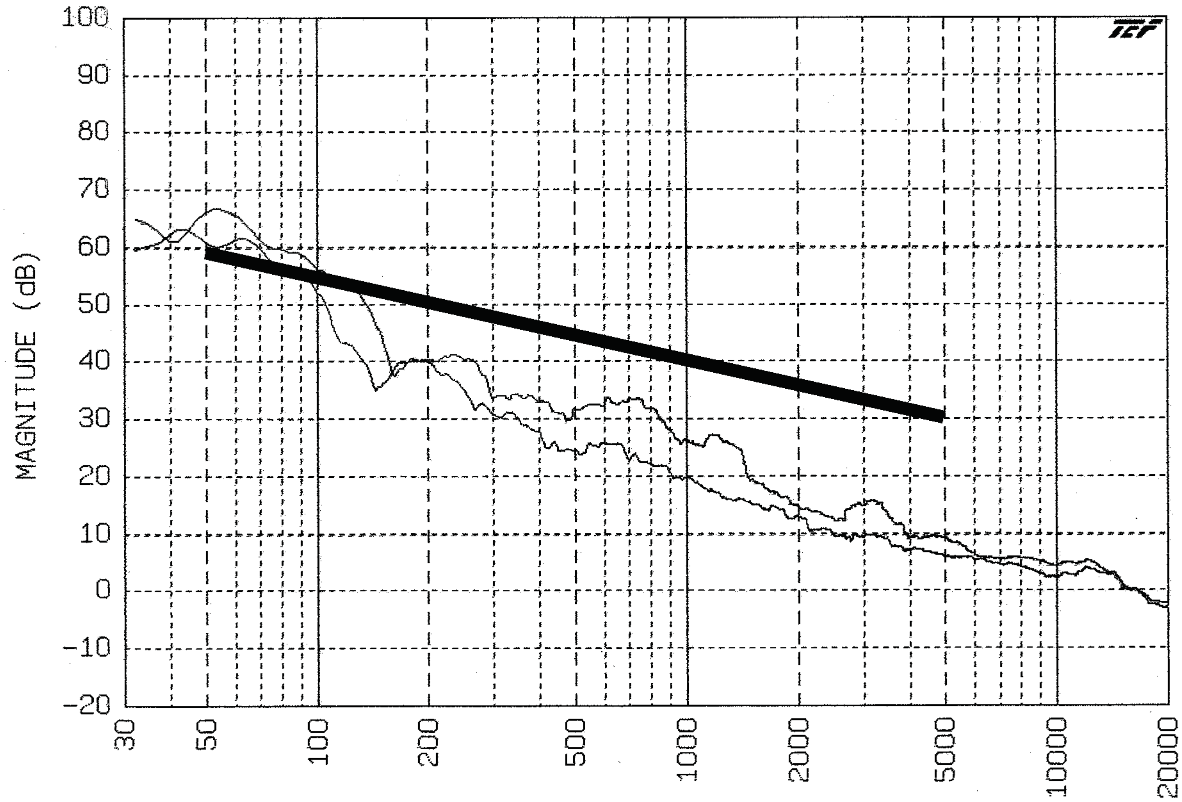


Figure 6

Ambient room noise measurement with sound masking target level added.

Transition zones and hotspots

! One of the most important tasks in your sound masking system design is to provide an even volume of noise in the open areas and a smooth transition of noise level as you move from a low noise area to a higher noise area. The even volume of noise in the open areas is dictated by proper placement of speakers and their firing angles. If you don't have enough speakers or they are not spaced close enough together, you will have to tap them at higher levels to get the overall noise level. The transition areas will require a lower volume of noise so the person entering from outside the building for example will not get hit with the full volume right away.

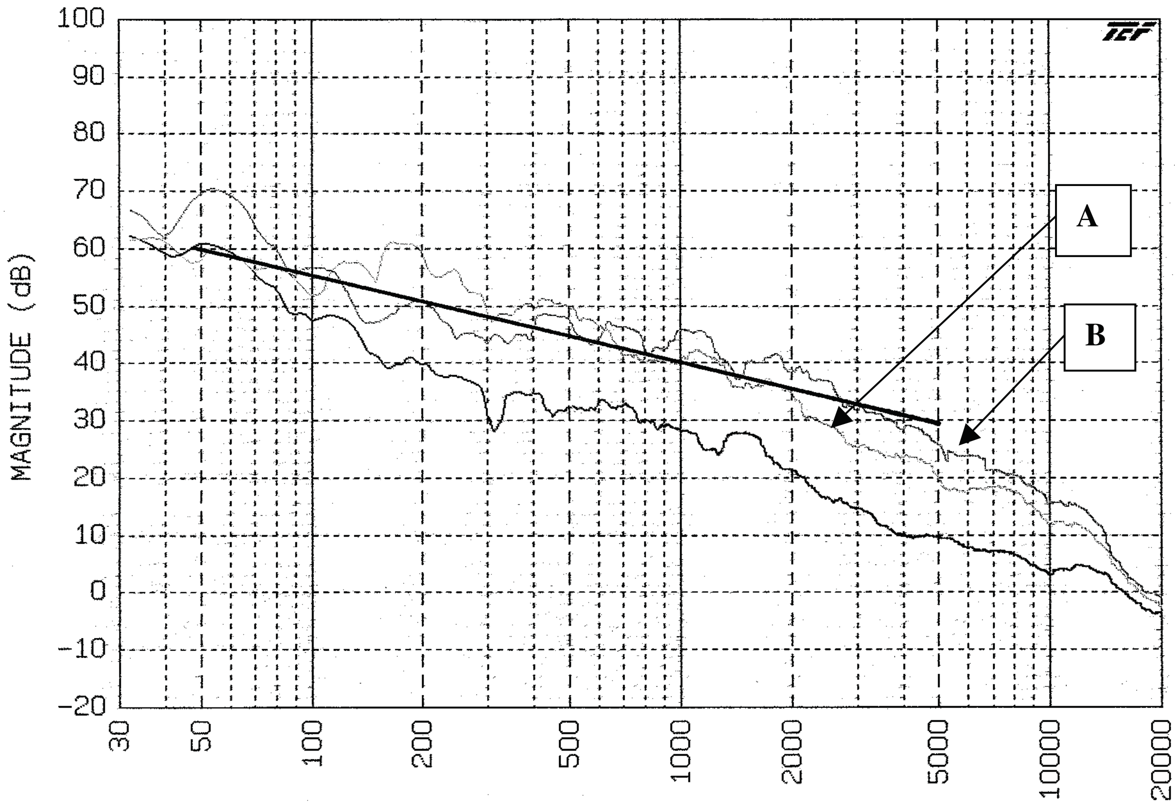


Figure 7

Ambient noise, masking noise, adjusted masking noise and masking noise target.

Turning the System On

After establishing your ambient noise level (lower line) and your target masking level (upper straight line) the system is ready to be turned on and initial equalizer adjustments can be made. To start, your equalizer settings will probably be set for flat response. This was the case for the line labeled A. The masking level can now be fine tuned to get as close to the target level as possible. Line B represents a first pass at adjusting the equalizer to shape the masking level. Keep making adjustments until you get as close as you can. You can use the equalizer to roll off the high and low end with filters if the unit has that capability.

Now you can listen and make adjustments. This part is very subjective, and more than one listener is recommended. Once you have achieved the desired level, record the equalizer and amplifier settings. You should be able to record the equalizer settings by saving them electronically. For the amplifier you can use digital voltmeter (True RMS reading) to measure AC voltage from the output of the amplifier and write that number down. The reading won't be accurate because the meter can't read that voltage at that many frequencies. For our purposes, it really won't matter. The reading will allow you to adjust the amplifier to the same level as before. If you really want to know the voltage level, you will have to use an oscilloscope. This is also the only way to see if there is any clipping or distortion. Whatever noise generator you use should be checked for clipping. If you didn't allow 50% headroom for your amplifier you should check for clipping and/or distortion.

At this point you know the ambient level and the target level that you adjusted for. The next step is to determine how you will slowly raise the masking level from just above ambient to the adjusted target level. If you are using an electronic equalizer with a built in noise generator that was made for sound masking you will probably be able to do this electronically and remotely.

It should have 8 or more built in equalizer settings that will allow you to raise the level no more than 2 dB each day. This is done so that no one will notice the slight increase each day. A ramping up period of five or more days is recommended. The increase should also occur when the building is unoccupied, like early in the morning or late at night.

If your equalizer will perform this function automatically, you would need to go to the job site each day and make the amplitude increase, with your RTA, until you reach the target level. The added expense of the sound masking equalizer/noise generator will far outweigh the cost of sending a tech to the job site everyday.

References

1. R. Kring Herbert, Open Office Acoustics, ASTM (American Society for Testing and Materials) subcommittee E33.02, Dec. 1998
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3. Glen Ballou, Handbook for Sound Engineers, pp. 203-209, 1260-1264, Focal Press, ISBN 0-7506-80331-0, 1998

ABOUT THE COMPANY...

In 1930, the **QUAM-NICHOLS Company, Inc**. was founded in Chicago, Illinois by J.P. Quam and Frank Nichols. In the height of the Great Depression, J.P. Quam brought his knowledge of phonograph motors and electronics and Frank Nichols his metalworking skills together to form a company that has seen generations of dramatic changes in the communications industry.

In the '30's, much of the manufacturing of "store-bought" radios was done in the Midwest. Quam-Nichols was the original equipment manufacturer (OEM) for the speakers found in most of the brand name radios of the time. A few years later, we did the same for another new technology called television. Looking back in time and viewing the growth of the radio, television and entertainment industries, we're proud to say that Quam-Nichols played an important part.

With a strong manufacturing base and well-trained workforce already in place, we chose to emphasize our core strengths and adapt our business plan to the changing market. For over eighty years, we've been based in Chicago, and we remain successful. Our original guiding principles of: Legendary Reliability, Superior Customer Service and always an Outstanding Value are enhanced by another critical factor- it's *Made in Chicago, by Chicagoans*!

Today, we continue to design and manufacture a wide scope of loudspeaker and installation solutions for the changing installed sound industry. If the project involves signaling, sound masking, voice or music, look to Quam as your 'problem solver'. Visit us on the the Web at: www.QuamSpeakers.com or give is a call at 1-800-NEED-NOW.

