



## Technology Behind NoiseBuster Superior Audio Response

The NoiseBuster® noise canceling headphone has been specifically engineered for superior audio response. Users of the product will enjoy not only peace and quiet but excellent sound quality from music as well as in-flight entertainment. The following is a technical discussion of audio response and the requirements for good sound from headphones and noise canceling headphones.

### **"Flat" is the goal...**

With audio equipment, it is the general rule that the frequency response of the device should be flat for most accurate reproduction. This is most certainly the case for electronic items such as amplifiers and CDs. Loudspeakers are a more complex case, as the sound perceived by the ear comes not only directly from the speaker to the ear, but also from reflections due to off axis sound bouncing around the living room and arriving at the ear from many directions (the diffuse sound field). Even so, the direct response is usually designed to be flat and the off axis response is designed to be flat in the mid range and fall away smoothly at high frequencies.

### **Headphones are very different...**

The natural response of a headphone with a leatherette type sealed cushion is for an extremely imbalanced response with an excessive bass level. If the headphone is altered to produce a flat frequency response (as measured by a microphone at the ear) it would sound very unnatural. This arises because the ear distorts the sound we hear. The shape of the outer ear and the characteristics of the ear canal act as resonant cavities that boost or suppress various frequencies. These characteristics depend upon the direction of arrival of the sound at the ear and also vary from person to person. The brain has evolved to use these clues as part of its ability to sense the direction of sound arrival and can 'hear through' the frequency response alterations to perceive the sound as having a natural balance.

A headphone changes this. Being in close proximity to the ear and often pressed flat against it, the alterations that the outer ear would normally impress upon the sound are suppressed or eliminated. Moreover, the sound arrives from just one direction, that of the headphone speaker. This leads the brain to misinterpret the headphone response as having an unnatural balance. To overcome this, the headphone response is deliberately altered so that it is no longer flat in an attempt to artificially put back some of the aberrations that the ear would normally introduce to the sound and thereby fool the brain into perceiving a more natural frequency balance.

### **Various approaches...**

There are many views on how to introduce aberrations into a headphone's response. One approach is to measure what the response would be at the ear canal entrance to a frontal sound source and to arrange for the headphone to reproduce this response at the ear canal entrance (free field response). Another approach assumes that sound normally arrives from multiple directions and so an average response is the correct one (diffuse field response). Another combines the two. Yet another uses a subjective assessment of the level of noise in third octave bands, adjusting the drive level to the headphone until the loudness from the headphone equals that of the loudness from a loudspeaker. These various methods have their pros and cons and one of the problems is that they can produce a response that is too analytical. The listening experience when using headphones tends to result in a more intense focus on the music, particularly since the sound appears to be localized somewhat inside the head. With some of the more analytically 'correct' balances, this can make the music sound hard and fatiguing.

### **Noise cancellation poses additional challenges...**

A further consideration arises with respect to noise canceling headphones, in that they are intended for use in noisy environments. Although the low frequency noise is considerably reduced by the action of the noise cancellation system, some residual will remain to partially mask the low frequency end of the music spectrum.

The method adopted for the NoiseBuster is therefore to subjectively adjust the balance of music so that it matches that perceived when listening to the music through loudspeakers in a room, the basis for how recordings are generally meant to be heard. Furthermore, the bass response of the NoiseBuster has been elevated slightly to compensate for residual uncanceled background noise. This compromise avoids the excessive bass level of similar competitive headphone where the response has not been adequately compensated, or the hardness in the sound quality of some other headphones.

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