EQUALIZATION AND EQUALIZERS

by Michael R. Lane

As this article is intended to offer understanding on a confusing subject to many who may not have a background in recording or electronics, it is presented in a very non-technical way.

For the collector of older records, contemporary ones too, probably no subject is more confusing than equalization and equalizers. Equalization in its broadest sense means altering the level of one part of the audio spectrum (20 to 20,000 cycles per second) in relation to another part. A level control (volume) evenly increases or decreases the entire audio spectrum, while an equalizer increases or decreases only a part, sometimes a very narrow part, of the audio spectrum. Equalizers are sound-shaping devices, and equalization is the overall process of shaping sound. It is frequently abbreviated by the letters EQ. The subject is less confusing when equalization is thought of as being of two types -- adjustable and inherent. Additionally, the over-all context in which equalizers are used must be considered.

I ADJUSTABLE EQUALIZATION

The simplest form of equalizer, and one still found on some inexpensive radios and phonographs, is the "tone control", which merely decreases high frequencies and so gives the illusion of more bass.

The majority of "hi-fi" preamp/receivers have the now traditional bass and treble controls. These increase or decrease the bass and treble separately and are usually referenced to a frequency of 1000 cycles per second. More complex refinements of these controls are increasingly encountered. Substitution of multi-position switches for the more usual bass and treble potentiometers produces better signal tracking, accuracy and reliability, although the advantage of the continuously adjustable potentiometer is lost. A mid-range control, boost or cut, is sometimes added, and in a few preamp/receivers the frequency at which the controls become operative is switch selected. For example, the treble may have a "1000" and a "5000" (cycles per second) setting, which are the frequencies above which the treble control becomes functional. The bass may have a "1000" and a "100" (cycles per second) setting which are the frequencies below which the bass control becomes functional.

"Rumble" filters (low-frequency cut-off) and "Scratch" filters (high-frequency cut-off) will also be found on many preamp/receivers. These may be simple on/off switches or multi-choice switches which give a variety of frequencies at which the cut-off filters will function.

In addition, the "loudness" control with one or more different settings is very common. It is normal for the human ear to be less sensitive to low or high sounds at low volumes; the loudness control compensates for this by boosting the areas where hearing is weak at low listening levels. Audio purists, however, rarely like or use them.

The multi-channel graphic equalizer is now quite common and, in some cases, it is being built into preamp/receivers. The term "graphic" refers to the fact that the switches show peaks or dips in the sound range as if they were plotted on a graph. Almost all professional recording consoles employ a "standard" five-band equalizer of this type. The visual display of the switches can be very useful when it is necessary to have an exact repeat of a sound setting. The 10-channel multi-graphic equalizer with octave-wide bands is becoming very common and may be the best compromise between flexibility in results and complexity in use. Half-octave, third-octave or even narrower band multi-graphics can be beneficial in professional installations and in sonic restoration work, but as the number of channels increases, the multi-graphic equalizer becomes much more complex to use.

Most versatile are the parametric equalizers. They are somewhat similar to the multi-channel graphic type, but give the user three separately adjustable "parameters" in each channel. Like the graphics, they divide the audio spectrum into frequency bands, and the level (or volume) of each can be separately controlled. Unlike the multi-graphics where each band is fixed in frequency, the parametric can shift this band, within limits, higher or lower in the audio spectrum. Also, the shape (broadness or narrowness) of each frequency band can be controlled from very broad (several octaves) to very narrow (a small fraction of an octave). These three variable parameters (level, frequency and "width" or shape) give the parametric equalizer tremendous capabilities in dealing with difficult problems such as the resonances in acoustic recordings. The very versatility of the parametric makes it difficult to use properly since it has an almost infinite number of sonic combinations, and, without great care and skill, the elimination of one obvious problem can introduce others more subtle. The quasi-parametric, which is the type generally available on the consumer market, is not recommended because the three adjustable parameters are interacting; adjustment of any one affects the others. The true parametric, on the other hand, has non-interacting parameters and is easier to use, both in repeating a previous setting and in the initial adjustments. Generally, we do not recommend the use of parametric equalizers by anyone other than the most dedicated audio/sound buffs because it takes a great deal of time and experience to learn their operation. The mere use of very complex equipment, such as parametric equalizers, does not automatically guarantee good results. When used by inexperienced operators, the results are frequently exaggerated and unnatural.

The adjustable "notch" filter is a very useful type of specialized equalizer. With its very narrow band-width and deep cut (40 db or more) it can remove 60 or 120 cycle hum, and cutter whistle, a problem on many early electric recordings, and do this without any apparent effect on the over-all sound. These units are available separately on the professional audio market, or the results can be duplicated with a true parametric equalizer. Notch filters can be of great benefit in the reproduction of 78's.

The various sound-shaping equalizers discussed above are designed to be user operated and give the user the ability to produce sonic results as he chooses. Their use is indispensable in working with 78's and many early LP's. The best of modern LP's generally need little, if any, user equalization, although it's nice to have it available.

II. INHERENT EQUALIZATION

Three of the most common media of sound communication for the music lover are FM radio, tape recordings and phonograph records. Each of these has a type of inherent equalization. Part of the confusion in talking about equalization comes from not clearly distinguishing between this inherent equalization and the adjustable, or user, equalization.

In the creation of the FM signal, tape recording or phonograph record, a "fixed" equalization is introduced, the purpose of which is to improve sound quality. Without going into the technical aspects (the reader is referred to "The Audio Cyclopedia" by Tremaine, and other other standard references for technical details), the physical nature of magnetic tape and phonograph records, as well as the nature of analog signal processing, require that the treble be boosted and the bass be cut when tapes and records are made. When they are reproduced, the playback equipment must reverse this process by cutting the treble and boosting the bass in the exact proportions that they were previously altered. When everything is done correctly, the result is a faithful reproduction of the original sound, with less distortion, a greater dynamic range and lower noise than would be possible if this inherent equalization were not used.

A. FM

With FM the equalization introduced at the transmitter is called pre-emphasis and is an increase in the level of the higher frequencies. In the FM receiver the playback equalization is called de-emphasis and is an exact reverse cut in the level of the higher frequencies. A good deal of FM's improvement over AM is a result of this inherent equalization. It has been standardized since the beginnings of FM, has never been much of a problem, and is taken for granted.

B. TAPE

With tape recorders the situation is somewhat similar, but the inherent equalization affects both bass and treble, unlike FM, which affects treble only. The inherent equalization used on tape is now standardized on the NAB curve but has varied in the past, especially between the U.S.A. and Europe. Serious alterations of sound occur when a tape recorded with one type of recording equalization is played back on a recorder using different playback equalization. Additionally, tape recorders need occasional adjustments of the recording and playback equalization as well as adjustments of the tape-to-head geometry. Most often the recording equalization is adjusted by referencing it back to the previously adjusted playback equalization, which in turn was adjusted from a master alignment tape! If the alignment tape and all the workmanship are of high quality, there is no problem. Unfortunately, alignment tapes come in differing degrees of accuracy, and they can be degraded by improper use. Further, the technician doing the alignments may be a bit sloppy -- all in all, the recorder's playback equalization may differ considerably from the NAB standard. When this happens, the poor results are usually partially cancelled out insofar as that particular recorder is concerned, when the recording equalization is then adjusted to give flat output -- referenced to the incorrectly adjusted playback equalization. The net result is that a tape recorded and played back on this same machine sounds fine, but when played back on a different machine with true NAB playback equalization, it may sound very different. These problems are frequently serious in mass-produced products -- especially cassette decks -- and are a partial explanation as to why tape recordings exchanged between collectors of rare records may be poor. Another cause is the lack of a "flat" playback system, but more about that later.

Quality professionals minimize these problems by using recorders with selectable playback equalization to compensate for differing recording equalization curves, by accurate alignment of the recorder, and by recording test reference tones on master tapes so that the playback recorder's response may be fine adjusted for an exact reproduction of the original tape. Unfortunately, even here plenty of sloppiness exists.

C. RECORDS

From the preceding it can be seen that inherent equalization is rarely a problem with FM radio but can cause some problems with tape recorders. Unfortunately, with records the problems are many times worse. The inherent equalization of records consists of a treble boost and a bass cut when the recording is made, and a treble cut and bass boost when the recording is played back. Just as tapes use the NAB standard, records NOW have their own standard -- the RIAA curve.

Many record companies now have their recording engineers add what we call "recording engineer equalization" via equalizers, mixing techniques, etc., so that when the record is played on a "low-fi" machine it will sound more brilliant! Of course, they also do many other types of sonic alterations and produce sonic effects which do not exist in real life. Frequently there is no way to remove these effects if you don't like them. This is not necessarily objectionable if the record jacket honestly states what has been done so the record buyer knows before purchase, but this is almost never the case.

The biggest problem for the collector of 78's and early LP's is the great variety of recording equalization curves used by different companies at different times. This requires that your playback equipment have a variety of playback equalization curves to match the original recording curves. It is also important to know what curves were used by what companies and at what times! Many of the older vacuum tube preamplifiers had 4 or 5 positions of playback equalization. Some even had separate controls for playback treble equalization (Roll-off) and playback bass equalization (Turn-over). With these units, particularly the versatile and justly famous McIntosh C-8 preamps, a good approximation of correct playback equalization was possible if you knew what characteristic curves were used in the actual recording. Some common terms for these differing inherent equalization curves were NAB, AES, ORTHO, FFRR, OLD 78, etc.

In modern audio systems, record playback equalization is truly inherent -- locked into the standard RIAA curve, but with older preamps it was adjustable, within limits, so the user could control the results, if not from actual knowledge of the recording's equalization, at least by ear. Modern preamp/receivers with their locked-in RIAA equalization are totally inadequate for playing 78's and older LP's accurately. Of course, some approximations are possible by the use of conventional tone controls. A multi-channel graphic equalizer can help quite a bit, and when the preamp/receiver is modified with a toggle switch which gives either RIAA or flat treble, the results can be fairly good. Still, the best results are possible only with a high degree of control over the "inherent" playback characteristics, both treble (Roll-off) and bass (Turn-over); these should be independently adjustable.

With the acoustic recording process (prior to 1925), inherent electrical equalization did not exist, but the characteristics of mechanical recording produced their own type of inherent "equalization" --unfortunately with almost infinite variability and particularly obnoxious horn resonance. Even here, very flexible playback equalization (adjustable, not inherent), coupled with a multi-channel graphic equalizer, or, better yet, a true parametric equalizer (even with its great difficulty of use), can solve most of the problems of sonic balance.

Well, from all of the above, it looks almost hopeless to try to reproduce old records faithfully to the original performance by a logical and reasoned approach. Many collectors don't even try. They simply play the records with whatever equipment and inherent equalization they have and use whatever adjustable equalizers they have to make it sound as good as they can. By adjusting bass and treble controls, perhaps using a multi-graphic equalizer, and correcting pitch if they have a variable speed turntable, the results sound okay to their ears in their particular listening room. Collectors become very skillful with this approach and the results are frequently very pleasing. It's the least expensive, easiest and fastest way to go, and many times works fine. We say, do as you are doing and more power to you, if this is your approach.

III. CONTEXT OF EQUALIZER USE

For the serious collector desirous of exchanging meaningful tapes with fellow collectors, and desirous of authentic and repeatable results, as well as for the professional engaged in sonic restoration, it is, as the saying goes, a whole new ball game. The motivations, psychological factors, and musical or artistic use, as well as the context of use, are crucial in using equalizers. We shall confine our discussion to the context of equalizer use, in which there are two major and related problems: (A) a "flat" playback system and (B) the hearing of the user. The other elements are a very broad subject by themselves and are beyond the scope of this article.

A. "FLAT" PLAYBACK SYSTEM

A performance recorded on some perfect recording medium on a perfect recording system and played back on a perfect reproduction system would be a perfect re-creation of the original performance. Assuming this is the objective, which is not always true,such perfection can be approached, but never fully reached, due to limitations in the recording medium, recording system and playback system. Now, the person playing back a record, or working in sonic restoration for that matter, has no control over either the original recording medium or system; he can only control the playback system. Changes made in the playback, however, can greatly help to approach the ideal and compensate for many problems in the original recording. Such work, if pursued with the objective of authenticity to the original performance, is both art and science. However, to have any repeatable meaning, the playback system must be "flat".

Assuming high quality audio equipment, the weakest link in the playback system is the speaker/room interface. To greatly minimize this problem, and possibly correct for other playback deficiencies, a multi-channel graphic equalizer placed just before the power amplifier is essential. Ideally, it should be adjusted with a real-time spectrum

analyzer with all equalization controls set flat, or out of the circuit. Most graphic equalizers come with test records and instructions which are satisfactory, but not as accurate as the real-time analyser. This speaker/room equalizer, once adjusted, should be thought of as an inherent-type equalizer to correct the playback system and listening environment deficiencies. It should be re-adjusted only if the playback system or the listening room undergo some change. (It is also possible to adjust it to compensate for hearing problems for a particular person.)

Adjustable multi-channel graphic equalization for sonic improvement of source material should be done with a separate multi-channel graphic equalizer located earlier in the playback system and should not be combined with the speaker/room equalizer. Generally, an octave-width 10-channel graphic equalizer will do the speaker/room job, but for greater accuracy or for extreme problems, a one-half or one-third octave graphic equalizer may be better. All equalizers, except for the speaker/room equalizer, should come before any tape recorders so that you can tape the signal that you actually hear. The exception is the speaker/room equalizer which must come after any tape recorders; otherwise, you will be taping the correction characteristics which apply only to your speakers and your listening room.

This speaker/room equalizer is the "sine qua non" of a standard reference playback system and, while not correcting subtle differences in audio playback systems, at least can give a fairly good standard. Without a "flat" playback system, equalization applied to correct sonic deficiencies in the source material also corrects for any sonic deficiencies in the playback system and listening room, and the results are meaningless unless played back on that same system in that same room. Professional recording studios try to have the flattest possible playback system for this very reason. It is this lack of a flat playback system, coupled with variations in recorder alignment and inherent equalization, which cause the sometimes erratic results when collectors exchange tapes of rare records. Of course, if a recording is made, or sonically restored, using a flat playback system and then played back on one that isn't flat, the results can be very different. The serious collector, sonic restorer and recording studio can't know the sonic environment of the ultimate listener to their work, but while doing their work, they can use a "flat" playback system, thereby setting a standard for reference.

B. HEARING OF THE USER

Also important in the context of equalizer use is the hearing of the user. Serious work should not be done when the hearing is temporarily impaired by a cold or other illness. Moderate high-frequency hearing loss can be partially compensated for by establishing a correction factor. If the playback system is flat on a real-time spectrum analyser but sounds dull to the user, a correction factor can be introduced while a recording is being processed. For example, if the treble control is

advanced so that a record of known high quality sounds good and natural to the worker, he can then rebalance the sound of the record being processed with reasonable accuracy. Before taping the results, however, he must remove the correction factor if it occurs in the audio chain prior to the tape recorder. Some may choose to introduce a correction factor for their hearing after the tape recorder, say at the speaker/room equalizer and leave it in permanently. The only disadvantage of this arrangement is that others, with no hearing problem, will not hear the correct sonic balance on anything played through the system in question; however, the taped results played on another system would be correct.

With distorted or garbled hearing, or ringing in the ears, the problems are more severe, but, frequently, working at low sound volumes reduces these hearing defects. If this is so, then a "loudness" equalizer, preferably a variable one, should be used to compensate for the normal high and low frequency loss at low volumes. Prior to recording the results in permanent form, the "loudness" equalizer should be switched off. Advances in medical science and electronics have made a number of high quality hearing aids available. For many persons these can make dramatic improvements in hearing, even in the subtle areas of phase shift and perception of harmonic distortion. Great care should be exercised in using equalizers, especially multi-graphics and parametrics, as high frequencies can be boosted to a level which in time can cause hearing loss.