THE PA BIBLE

ADDITION NUMBER FOUR
UNDERSTANDING EQUALIZATION AND THE VARIOUS TYPES OF EQUALIZERS

Material for this addition was supplied by Larry Blakely, a well known audio and recording industry consultant and writer.

Larry recently completed a book on high-fidelity equipment, and has written articles for Modern Recording, Stereo Buyers Guide, Hi-Fi Buyers Guide, Tape Deck, Recording Engineer/ Producer, Modern Recording Buyers Guide, Studio Sound and Billboard. Larry is the co-founder and current president of the Creative Audio and Music Electronics Organization, and is on the Board of Industry Presidents of AMC and NAMM, and a member of AES. He is exceptionally well qualified to discuss the subject of equalization, having participated in the design, marketing, and application of equalizers for recording studios and for the live entertainment industry.

In prior P.A. Bible material we have discussed the general topic of sound systems with emphasis on certain topics relating to loudspeakers and microphones. In this addition we will cover the various types of equalizers, their operational characteristics, equalizing for enhancement, and system equalizing.

It is not our intention to discuss applications in great detail, especially the fine art of room equalization. We do want to acquaint you with certain basic concepts and guidelines that will enable you to jump in and learn by experience.

INTRODUCTION

There are many different types of equalizers that are used for a wide variety of applications. Equalizers will range from simple "tone controls" (bass and treble) which you will find on almost every record player or hi-fi system to the more sophisticated types of equalizers, such as the graphic or parametric. Equalization can place a great deal of flexibility at your fingertips. When used properly equalizers are excellent tools, but they are often misused and provide less than desirable results.

To help one determine if he needs an equalizer, as well as which type he should obtain, it is very helpful to have an overview of equalizers: how they work, the various types available, which types are best suited for various applications, and some simple guidelines for their use. For those who already understand this basic information, this will serve as a review, while giving the un-informed reader new knowledge that will greatly aid him in intelligently choosing and using equalization.

If you are using audio equipment and desire to hear something louder, you turn up a level (volume) control. When such a control is adjusted for a louder level, the level of all audible frequencies (entire audible frequency spectrum) is increased by the same amount. This simple level control is no respecter of frequencies; turn it up and the result is an audible increase in overall loudness (over the entire audible frequency range). However, when you turn up the "bass control" on a record player, only the low frequencies are increased in level, which will usually make the sound richer and fuller. When you turn down the "bass control", low frequencies are decreased, and the sound is usually thinner or even tinny. When you turn up the "treble control", high frequencies are increased, and the sound becomes bright or brilliant; turn it down and the sound will be dull and sometimes even muddy. These common bass and treble controls are "equalizers". In simple terms, an equalizer is a volume control (to increase or decrease level) for specific frequency ranges. To further expand our understanding, let us take a close look at frequencies and the audible frequency spectrum.

FREQUENCIES

Sound is made up of vibrations. These vibrations are referred to as "cycles". The number of these vibrations (cycles) that take place in one second are referred to as "cycles per second". One vibration (cycle) in one second would be called one cycle per second. 15,000 vibrations in one second would be 15,000 cycles per second. The number of cycles per second determine the actual frequency (pitch) of any audible sound. For those who are musicians, concert "A" is 440 cps (cycles per second).

For many years the term "cps" (cycles per second) was commonly used in the music and audio industries. In recent years the term "cycle" was substituted for another term called "Hertz", abbreviated "Hz". Hertz (Hz) is the unit of measure of frequency (cycles per second). One Hertz is one cycle per second. The range of human hearing is usually considered to be from 20 to 20,000 Hz for a person with very good hearing. When frequencies are in the thousands of Hertz, they are often indicated with a "k" (designating thousand) prior to the symbol Hz. Therefore, 20,000 Hz would be indicated as 20 kHz.

OCTAVES

As mentioned earlier, concert "A" is 440 Hz. If a musical note one octave higher were played, it would be "double" that frequency or 880 Hz. If a note were played one octave below 440 Hz, it would be "half" of that frequency or 220 Hz. Therefore, double the number of any frequency and you have one octave above; halve the number of any frequency (divide by 2) and you have one octave below. Much of music is generally referred to in octaves or portions of an octave.

FUNDAMENTALS AND HARMONICS

Musical sounds are made up of "fundamentals and harmonics". The fundamental frequency will sometimes (but not always) be the most powerful member of the harmonic series of a given instrument. The harmonics are multiples of the fundamental frequency. The 1st harmonic is the fundamental frequency, the 2nd harmonic is two times the fundamental frequency, 3rd harmonic is three times, etc. The harmonic structure of a musical sound has a great deal to do with its perceived qualities and/or texture (timbre). A typical relationship of fundamental to harmonic energy is shown in Figure #1.

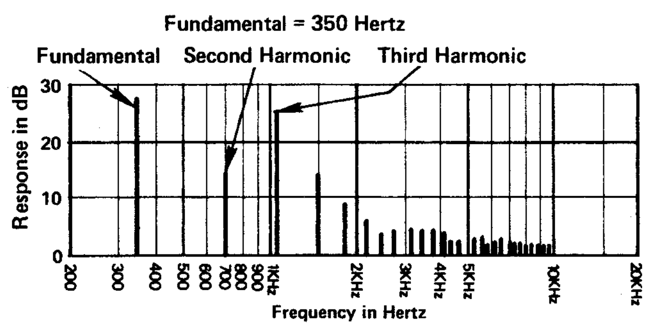

FIGURE 1 — Fundamental to Harmonic Energy Relationship

AUDIO FREQUENCY RANGE

Let us take a look at the audible frequency range to determine the location of commonly known sounds with respect to frequency. Refer to Figure #2 as you read the following

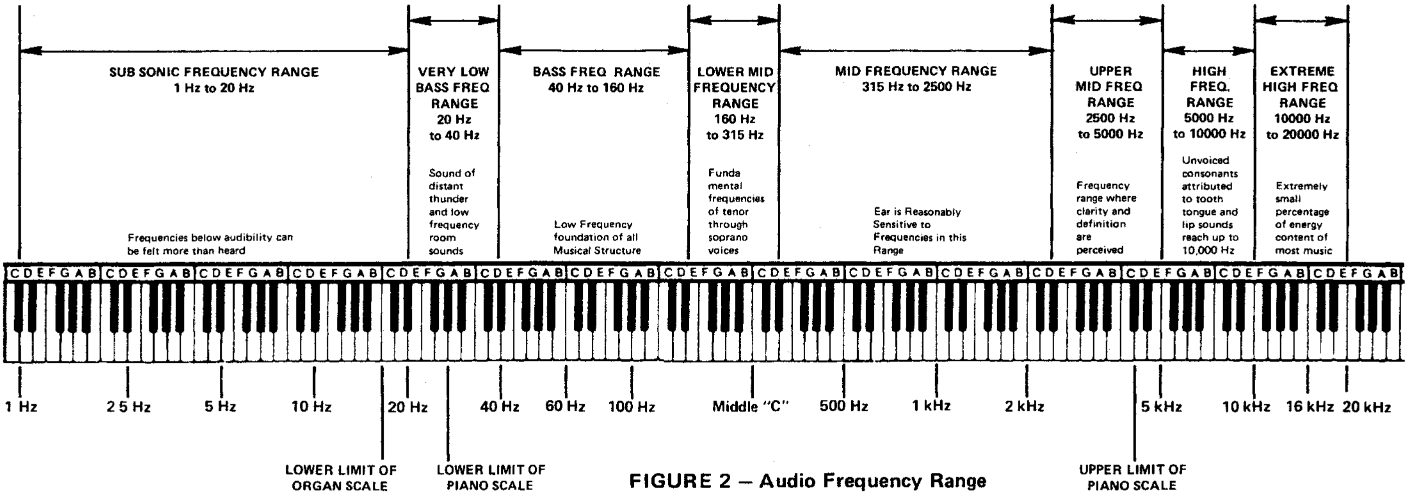

FIGURE 2 – Audio Frequency Range

to provide a visual aid. It was mentioned earlier that the range of human hearing is 20 Hz to 20 kHz. This would be the frequency range for a person with very good hearing. Most types of professional audio equipment will have a specified frequency response of 20 Hz to 20 kHz. For our purposes we will now investigate the frequency range from 1 Hz to 20 kHz.

Sub-Sonic Frequency Range – 1 Hz to 20 Hz (Approximately 4 Octaves)
In this portion of the frequency spectrum are frequencies that are usually not audible. One can *feel* their effect when they are at sufficiently high level as pressure sensations rather than as distinct musical tones. Some very large pipe organs and earthquakes have frequency components in this range.

Very Low Bass Frequency Range – 20 Hz to 40 Hz (1 Octave)
Examples of sounds with frequencies in this range are wind, room rumble, low frequency sounds from air conditioners, the sound of distant thunder, etc. Frequencies near 30 Hz are illustrated by the lowest fundamental frequencies of medium size pipe organs, the piano, and the harp.

Bass Frequency Range – 40 Hz to 160 Hz (2 Octaves)
Most of the low frequencies of drums, the piano, the organ, and string or electric bass fall within this frequency range. In this particular range is the low frequency foundation of all musical structure.

Lower Mid Frequency Range – 160 Hz to 315 Hz (1 Octave)
This octave is a transitional range *between* frequencies that would be perceived as bass and those that would be considered to be mid-range tones. Many of the fundamental frequencies of tenor through soprano voices and the lower frequencies of several instruments, such as the trumpet, clarinet, oboe and flute, are contained in this range.

Mid Frequency Range – 315 Hz to 2,500 Hz (3 Octaves)
The ear is reasonably sensitive to frequencies in this range. In fact, this range of frequencies, heard alone, would have a "telephone-like" quality. As most instruments are rich in lower harmonics, the majority of sound energy is found in the frequency range *up to* 2,500 Hz.

Upper Mid Range or Presence Frequency Range – 2,500 Hz to 5,000 Hz (1 Octave)
The ear is very sensitive to frequencies in this octave. A sense of clarity and definition is imparted to complex sounds by frequency components in this range. In fact, many horn type public address speakers are designed to deliver maximum energy in the 3,000 Hz region. The *apparent* loudness of a sound can be appreciably influenced by the frequencies in this region. Singing voices often have harmonics in this frequency range.

High Frequency or Brilliance Frequency Range – 5,000 Hz to 10,000 Hz (1 Octave)
This range makes things sound brighter, but there is normally little acoustical energy in this portion of the frequency spectrum. In fact, the highest fundamental frequency of musical instruments is approximately 4 kHz. These frequencies account for some clarity and brilliance; however, they are usually a small percentage of the total musical or speech energy. Often unvoiced consonants which are attributed to tooth, tongue, and lip sounds are high in frequency and reach up to the 10,000 Hz range.

Extreme High Frequency Range – 10,000 Hz to 20,000 Hz (1 Octave)
This is the top octave of the audible frequency range. It contains an extremely small percentage of the energy content of most music. Hearing loss associated with advancing age can remove an appreciable portion of the upper part of this octave. Only very high harmonics of some tones contribute to this region. The loss of most of this frequency range may not be noticed on much musical material – this is especially true of the upper *half octave* of this range. However, on very wide range frequency sources that are rich in harmonic content, the reproduction of this range can add a small but definite touch of realism.

EQUALIZER CHARACTERISTICS

An "equalizer" was defined earlier as a volume control (to increase or decrease level) of specific frequency ranges. When an equalizer is used to *increase* the level of a specific frequency range, it is called "boost". Likewise, when a certain frequency range is *decreased* in level it is called "cut". The amount a given frequency range is boosted or cut is typically indicated in decibels (dB). The decibel (dB) is the unit of measure for sound level (amplitude).

There are two basic types of equalization:

Shelving
Shelving is an equalization curve that changes in level until it reaches the "indicated frequency" at which point it levels off and changes no more. When illustrated, this curve looks like a shelf, hence the name "shelving". Once the indicated frequency is reached, all frequencies beyond will remain at the same level. A shelving equalizer is shown in both boost and cut modes in Figure # 3. The common bass and treble controls found on most types of hi-fi and inexpensive mixing equipment typically utilize shelving type equalization. Perhaps the most common indicated frequencies for these typical bass and treble controls are somewhere between 50 to 100 Hz for bass and 5,000 to 10,000 Hz for treble.

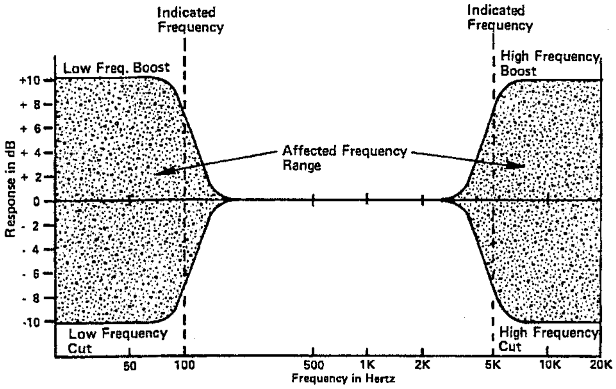

FIGURE 3 – Shelving Equalization Curve

Peak/Dip

Peak/Dip is a curve that starts at "0" (no change in level) and changes in level until it reaches its "center frequency" (maximum change in level) and then again changes in level until it returns to "0". When illustrated, this curve looks like a mountain or "peak" in the boost mode and a valley or "dip" in the cut mode. This type of equalization curve will provide maximum boost or cut at the center frequency as well as other frequencies close by, and will have less effect on frequencies further away from the center frequency. A Peak/Dip equalizer is shown in both boost and cut modes in Figure #4. Audio equipment with equalizers that have a "presence" or "mid-range" control (section) almost always utilize the peak/dip type of equalization curve.

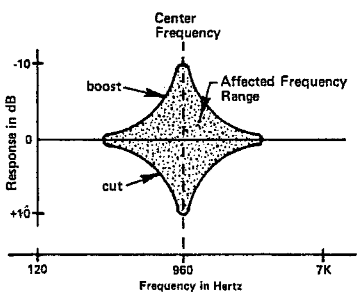

FIGURE 4 – Peak/Dip Equalization Curve

"Q" is another basic characteristic of equalization curves and pertains to both the shelving and peak/dip types. The technical definition of "Q" is beyond the scope of our purposes. Let us just say that "Q" is the property of an equalizer that determines the range of frequencies that are affected on either side of the center frequency in peak/dip type equalizers, and prior to the indicated frequency for shelving type equalizers. In Figure # 5 peak/dip type equalization curves are shown with both high and low "Q".

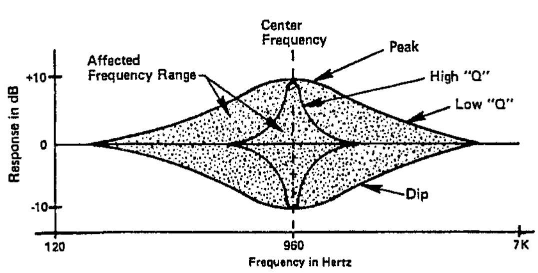

FIGURE 5 – "Q" of a Peak/Dip Equalizer

The "Q" on most types of equalizers is fixed and cannot be changed by the operator. However, some of the more elaborate types of equalizers (usually the peak/dip) have an additional control which will allow the operator to change the "Q". Shelving type equalizers are also affected by "Q" in that it determines the range of frequencies that are affected prior to its indicated frequency which is sometimes referred to as "slope". Figure # 6 shows shelving type equalization curves with both high and low "Q". The "Q" or slope of almost all shelving equalizers is fixed and not adjustable by the operator.

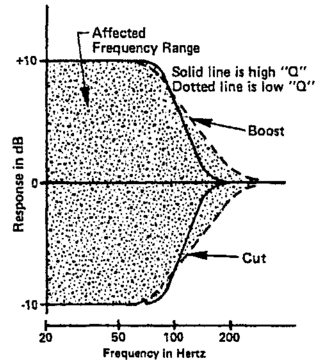

FIGURE 6 – "Q" or Slope of a Shelving Equalizer

BASIC TYPES OF EQUALIZERS AND THEIR APPLICATIONS

There are many types of equalizers available on the market to suit a wide range of applications. In many cases the addition of a specific type of equalizer to an audio system would provide a dramatic increase in quality, but often the user does not know that an equalizer would help. Again, there are those who desire to add equalizers to their systems, but do not know what type would best suit their needs. A real problem exists because many people purchase equalizers without any knowledge and are often sold equalizers that are far more elaborate and expensive than necessary. On the other hand, equalizers are frequently purchased which are not suitable or capable of performing well in a given application.

Equalizers are usually packaged in one of two ways; "inboard", which means that it is a part of another piece of equipment, such as a mixing console. "Outboard", sometimes referred to as "program" equalizers, are self contained equalizers that are usually self powered and can be patched (plugged) into almost any audio system.

Equalizers which utilize active components such as transistors or operational amplifiers are referred to as "active equalizers". When an active equalizer is connected to an audio system, there will typically be no loss in signal level when the equalizer is inserted into the signal path. Another less common type of equalizer, called the "passive equalizer", has no active electronic components and will cause a fixed signal (level) loss of several dB when inserted into the signal path. This is referred to as "insertion loss". Passive equalizers were the most popular type during the 1940's, 50's, and 60's, and some of these units are still available – usually second hand. There are also some sophisticated models of passive equalizers available for acoustic control and laboratory purposes. Passive equalizers must usually be terminated with specific impedances and have a fixed insertion loss. Passive type equalizers would not be an ideal choice for the unknowledgeable or new user of equalizers.

Tone Controls

Tone Controls are usually of the two knob type (one for bass and one for treble). Shelving equalization curves are most commonly utilized for this type of equalizer. The indicated frequencies are fixed and are typically somewhere between 50 and 100 Hz for bass and between 5 kHz and 10 kHz for treble. The "Q" or slope of these equalizers is fixed as well. The two knobs (controls) on this type of equalizer are for the amount of boost and cut that is available. The equalizer will have no effect at the "0" dB (no boost or cut) position which is usually at the center of rotation (rotary control) or center of travel (straight line control). These tone controls are actually a two knob (fixed frequency) equalizer. See Figure #7.

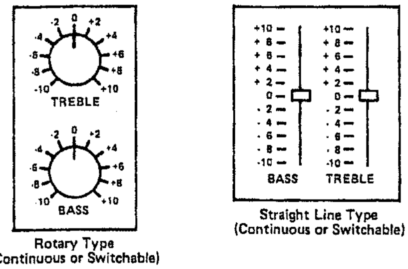

FIGURE 7 – Various Types of Tone Controls

Move the control in one direction for boost or in the opposite direction for cut. The available amount of boost and cut will vary depending upon the equalizer; however, it will usually be in the area of 10 dB of boost and cut (± 10 dB). Tone controls are found on almost every type of hi-fi equipment. Many types of mixers may have two knob equalizers on each input and/or on the main outputs. This is the most basic type of equalizer and can be easily used to enhance sound for a wide range of applications without the chance of getting into much trouble, and will usually provide very good results.

Two Knob Equalizers (Selectable Frequency)

This is a more sophisticated two knob (sometimes referred to as two band) equalizer which still has only two knobs and which will boost or cut two different frequency range simultaneously, just like the simple two knob "tone control". However, one or two additional controls are added to enable the operator to select various frequency ranges. A two knob shelving type equalizer that will select three bass as well as three treble frequency ranges is shown in Figure #8.

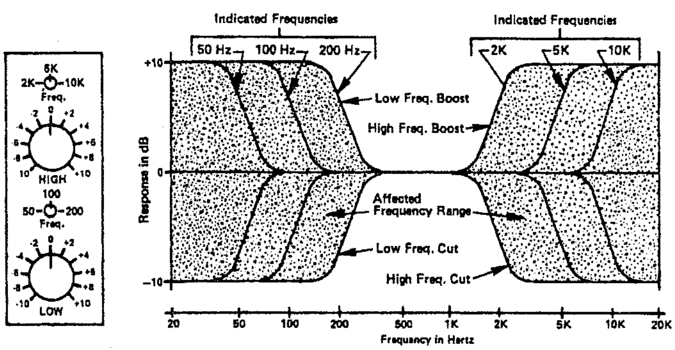

FIGURE 8 – Two Knob (six frequency) Selectable Frequency Equalizer

The "Q" of this equalizer is fixed. This equalizer will allow the operator to work closer to certain desired frequency ranges without âffecting as much additional unwanted frequency range. For example, a low frequency room rumble could be reduced by "cutting" at the 30 Hz frequency range. The common tone control bass knob (typically 100 Hz) would serve the same function, but it would probably cut desired low frequencies from the program. The particular frequencies that are provided along with the available amount of boost and cut are determined by the manufacturer. Any switchable frequency equalizer can be a fine tool in the hands of a user who understands where the various instruments, vocals, and other sounds are located in the frequency spectrum.

Three Knob Equalizers (Fixed and Selectable Frequency)

These equalizers have three knobs (bands) which will boost and cut three frequency ranges simultaneously (sometimes referred to as a three band equalizer). One knob is for low frequencies, one for high frequencies, and one for mid-range frequencies. Three knob equalizers typically utilize shelving curves for the high (treble) and low (bass) frequency ranges while using a peak/dip curve for the mid-range. A "fixed frequency" three knob equalizer is shown in Figure #9.

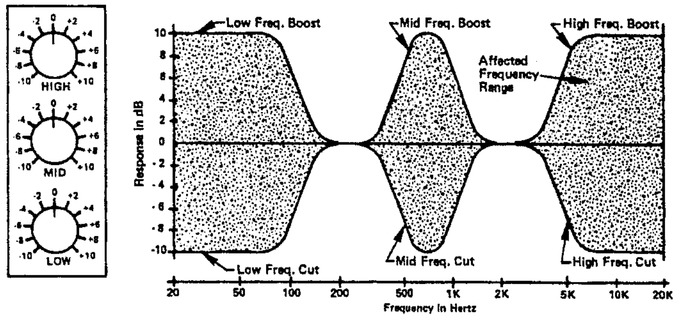

FIGURE 9 – Three Knob (three frequency) Fixed Frequency Equalizer

Another very common three knob equalizer also has fixed low and high frequency shelving curves but with a switchable peak/dip mid-range section as shown in Figure # 10.

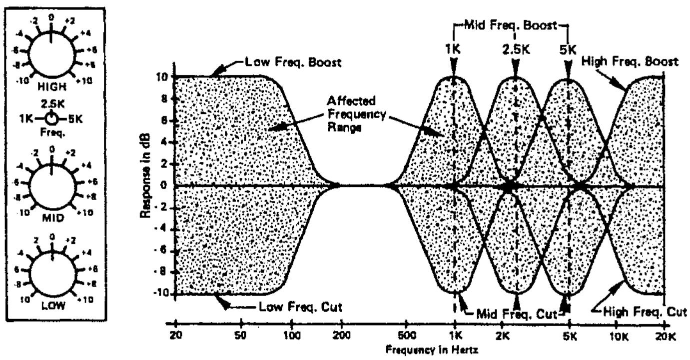

FIGURE 10 – Three Knob (five frequency) Equalizer with Switchable Mid-Range

Both of the equalizers in Figure # 9 and # 10 have fixed "Q". Again, the amount of boost and cut (in dB) as well as the available frequency ranges depend upon the manufacturer. Three knob equalizers add the flexibility of mid-range equalization to the low and high frequency ranges. This type of equalizer is typically found on higher priced mixing consoles and offers the user a great deal of flexibility.

Four Knob Equalizers (Fixed and Selectable Frequency)

Now we have four frequency ranges that can be boosted or cut simultaneously; low frequencies, lower mid-range, upper mid-range, and high frequencies. Most equalizers of this type utilize shelving for the low and high frequency sections, and peak/dip for both midrange sections. Almost all models of this type have switchable mid-range frequency ranges and sometimes even switchable low and high frequency ranges as well. In Figure # 11 there is a full blown, four knob selectable frequency equalizer.

This equalizer has ten frequency ranges with fixed "Q" that will allow the operator to boost or cut at frequency ranges that are somewhat close together. The available frequencies and amount of boost and cut depend, as always, upon the manufacturer. These sophisticated equalizers are typically found in the very expensive and more elaborate type of mixing consoles and in some models of outboard equalizers. Some equalizers of this type even have adjustable "Q" in the mid-range sections.

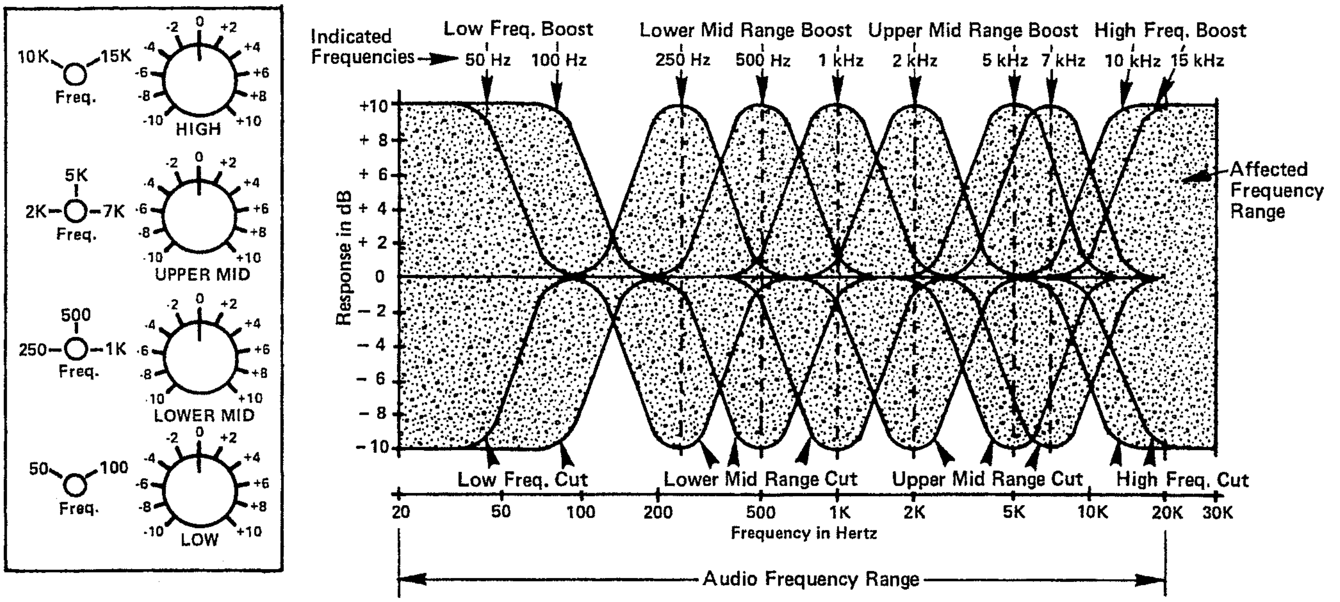

FIGURE 11 – Four Knob (ten frequency) Selectable Frequency Equalizer

Graphic Equalizers

All of the equalizers that we have investigated to this point have had the capacity to equalize in two, three, or four frequency ranges at the same time, depending upon the type. It is sometimes an advantage to have the ability to equalize in a larger number of frequency ranges at the same time. It can be easily seen that the two, three, or four knob equalizers do not have this capability. A "graphic equalizer" does have the capability of equalizing a large number of frequency ranges (usually 10 or more) at the same time. Graphic equalizers typically utilize the peak/dip type of equalization curve and the "Q" is usually fixed. Graphic equalizers have the ability to contour the sounds of different voices, effects, or music by boosting or cutting at a number of frequency ranges simultaneously. For example, equalizing a voice in the mid frequency range will add more presence and intelligibility while boosting the lower mid-range and bass frequency ranges will add warmth. If there are some low frequency, unwanted sounds like room rumble at very low frequencies, the 30 and 50 Hz regions can be cut to reduce the audible effect of these unwanted sounds. Now, all of these things can be done with the same equalizer that had the ability to boost or cut in a large number of frequency ranges (bands).

ISO Center Frequencies. The ISO (International Standards Organization) has established standard center frequencies for graphic equalizers. These specified frequencies are utilized by most manufacturers of graphic equalizers. It should be pointed out that an equalizer not using the ISO center frequencies is necessarily less desirable than one that does. Standardization of center frequencies enables the operator to use almost any graphic equalizer in the same way because it has the same exact frequency ranges available to equalize. This makes it possible to duplicate a certain sound or equalization setting at a different location when utilizing unfamiliar equipment.

One Octave Graphic Equalizer. Perhaps the most common graphic equalizer is the "octave" graphic equalizer. This is a graphic with usually ten frequency ranges that can be boosted or cut, with center frequencies placed at one octave intervals. Most equalizers of this type have fixed "Q". The ISO center frequencies for such a one octave equalizer are: 16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, and 16000 Hz. You may notice that there are 11 one octave ISO center frequencies. Most one octave equalizers do not have the 16 Hz frequency band because there is little or no musical energy at this range. A typical one octave equalizer along with its equalization curves is shown in Figure #12.

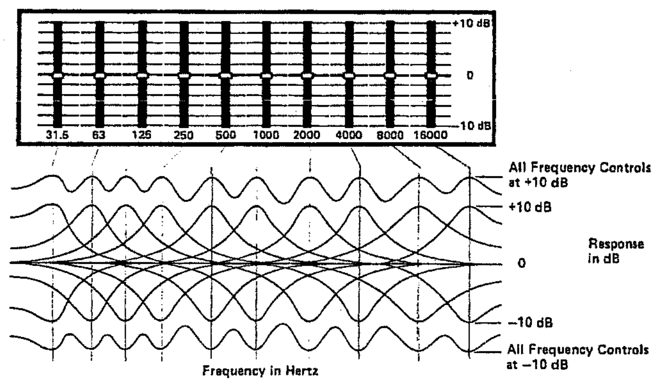

FIGURE 12 – One Octave Graphic Equalizer

1/3 Octave Graphic Equalizer. This graphic has three times as many frequency bands as the one octave type and will provide greater control over the frequency spectrum by breaking it up into smaller segments. This equalizer will typically have 30 frequency ranges that can be boosted or cut at the same time. Most equalizers of this type have fixed "Q". 1/3 octave graphic equalizers are widely used for speaker or room voicing, acoustic feedback suppression, as well as laboratory applications. The ISO center frequencies of the 1/3 octave equalizer are: 16, 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, 10000, 12500, and 16000 Hz.

1/2 Octave Graphic Equalizer. Often, for some applications, a one octave graphic equalizer will not equalize at enough frequencies, and the 1/3 octave equalizer is too elaborate and expensive.

This means that there is room for another equalizer in the middle. So for those who need additional frequency ranges over the one octave graphic, but who neither need the full flexibility nor can afford the 1/3 octave graphic, there is the 1/2 octave graphic equalizer. This type of equalizer is of the boost or cut type and usually has a fixed "Q". The ISO center frequencies for the 1/2 octave graphic are: 16, 22.4, 31.5, 45, 63, 90, 125, 180, 250, 355, 500, 710, 1000, 1400, 2000, 2800, 4000, 5600, 8000, 11200, and 16000 Hz.

It is common for one who realizes the flexibility of a graphic equalizer to say, "Boy, what I could do with that!". Graphic equalizers can be very valuable tools because they have the ability to equalize in a large number of frequency ranges (bands). This tool can also be a detriment because it can also do a great deal of sonic damage to a signal. We do not mean to discourage the use of these sophisticated equalizers; however, it is important for the user to make sure the equalizer is suited to his application and to operate it properly if he is to achieve the desired audible results.

Sweepable Frequency Equalizers

All of the equalizers mentioned previously have had either a small number or a large number of *fixed* frequency ranges (bands) which could be equalized. Utilizing these (fixed frequency) types of equalizers, one would first listen to the signal, then equalize at the nearest available frequency range to provide the desired effect. If one wanted to equalize a vocal in the mid-range and the equalizer would only boost and cut a 2 kHz and 5 kHz, it would be necessary to use one of these available frequency ranges (bands). In most cases the use of one of these two available ranges would probably improve the sound of the vocal, but the amount of flexibility would be restricted by the available frequencies on the equalizer. Suppose a mixing console had a four knob six frequency equalizer and the available mid-range frequencies were 800 Hz, 1.2 kHz, 2.5 kHz, and 5 kHz. We want to equalize for a particular type of mid-range sound on a vocal solo, and we find that it cannot be obtained with any of the available mid-range frequencies on the equalizer. One option is to keep trying outboard equalizers (perhaps a graphic) until you find one that equalizes at the right frequency to provide the desired sound.

Wouldn't it be nice if you could have an equalizer that would tune over a wide range of frequencies like a radio? Now it would be possible to adjust the center frequency of the equalizer (with a knob) until you had obtained the desired sound or effect. This would allow the selection of any center frequency within the equalizer's available frequency range. This is called a sweepable frequency equalizer. There are usually two knobs per equalizer section, one to tune (adjust) the center frequency over the available frequency range and another to adjust the amount of boost or cut (specified in dB). The "Q" for this type of equalizer is fixed. A simple one knob sweepable frequency equalizer would have equalization characteristics similar to the ones shown in Figure # 4, except that the center frequency would be sweepable (tunable).

It is a common feature to find three knob equalizers with fixed frequency high and low bands and a sweepable mid-range section. This type of equalizer will provide the operator with a great deal of flexibility. They are a very popular feature on many of today's mixing consoles. There are also two knob versions of sweepable frequency equalizers.

Parametric Equalizers

The sweepable frequency equalizers have fixed "Q". However, there are applications where it is desirable to be able to adjust the center frequency and the "Q" as well. Such an equalizer that has both tunable frequency and adjustable "Q" is called a parametric equalizer. The adjustable "Q" control operates in a tuning fashion similar to the adjustable frequency control. One can now tune the center frequency for the desired basic sound or effect, then have the additional flexibility of adjusting the "Q". By adjusting the "Q", the frequency range on either side of the center frequency can be restricted to that which provides the most desirable results. This equalizer will provide a great deal of flexibility for the knowledgeable user. A single knob version of the parametric equalizer would have equalization characteristics similar to the ones shown in Figure #5, except that the center frequency would be sweepable (tunable).

There are a number of versions of the parametric equalizer available. The three and four knob (band) versions are the most popular of the outboard types. Parametric mid-range sections are sometimes used in three and four knob inboard equalizers on mixing consoles.

Paragraphic Equalizers

These equalizers are a hybrid made up of the properties of both the parametric and the graphic equalizers, hence the word paragraphic. One may ask why one would desire something like this. There are some applications where many frequency bands must be equalized and where it is also desirable to be able to adjust the center frequency and the "Q" of the bands. The most common type of paragraphic is similar to a one octave graphic made up of ten frequency bands placed on one octave centers. Each of the ten frequency bands are tunable (adjustable) over its one octave range to allow the center frequency to be adjusted to anywhere within that one octave band. Once the center frequency is set the "Q" can be adjusted for that band to provide the desired effect. A paragraphic is shown in Figure #13.

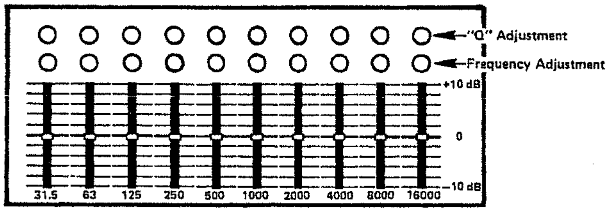

FIGURE 13 — Paragraphic Equalizer

Paragraphic equalizers are very popular for "room voicing" where there are often certain portions of the frequency spectrum with a peak or dip that may not coincide with the ISO center frequencies. Having the ability of adjustable frequency and "Q" as well will enable the equalizer to provide the right amount of complimentary boost or cut in the exact frequency range to correct the problem. This method will allow the corrective equalization to be specifically tailored to the problem or the room.

Sweepable Graphic Equalizer

An equalizer similar to the paragraphic is the sweepable graphic equalizer. This equalizer is identical to the paragraphic in every respect except it does not have adjustable "Q". Obviously, this equalizer is less complex and less expensive.

BASICS FOR THE USE OF EQUALIZERS

At this point you should have a good idea of the various types of equalizers available and their basic features as well as some of their ideal applications. Once you have reviewed this information and have selected an equalizer for your purposes, you have only just begun. Now you must know how to use it properly to realize its full potential. It is virtually possible to write a book on the operation and use of each type of equalizer that has been described. However, certain basic information will be of great benefit to you in your use of almost any type of equalizer.

KNOW THE FUNDAMENTAL FREQUENCIES OF VOICES AND MUSICAL INSTRUMENTS

It is possible to equalize the sound of an instrument or voice and not obtain the desired effect – if any effect at all. This is usually due to the fact that the boosting or cutting occurred at frequencies above or below the dominant energy of that voice or instrument. If you are to utilize equalizers effectively, you must know the frequency content of instruments and voices so you will know what frequency ranges can be equalized. For this purpose the chart shown in Figure # 14 may be used.

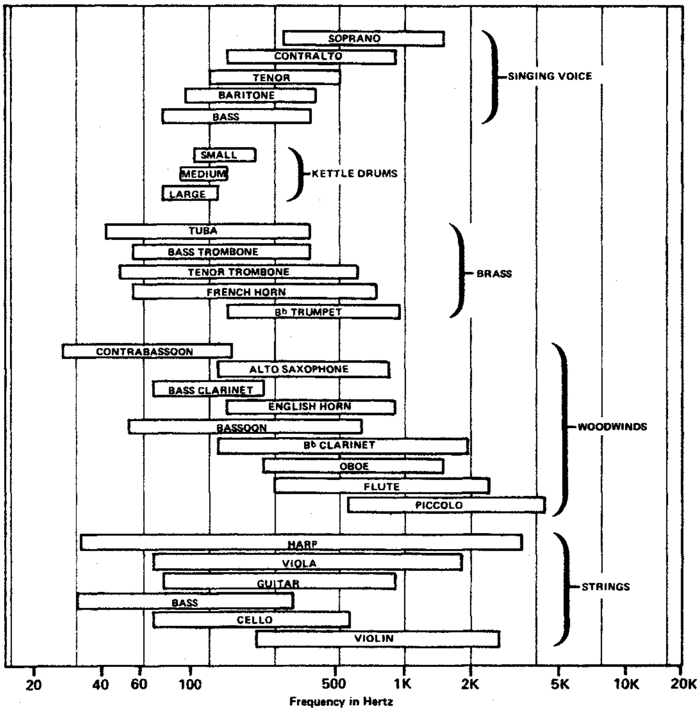

FIGURE 14 – Frequency Ranges for Fundamental Frequencies of Voices and Musical Instruments

It is important to point out that the information on this chart only applies to the fundamental frequencies. All musical sounds have harmonics which will go beyond the frequency ranges shown in Figure # 14. These harmonics affect the sound of voices and instruments; however, they are usually much lower in level than the fundamental frequency. At times good effects can be obtained by boosting or cutting in the frequency range of these harmonics rather than in the frequency range of the fundamental frequency. In any case, it is preferrable to always start your equalization in the fundamental frequency region. If you do not like the sound, try equalizing at surrounding frequencies until you get the desired effect.

Let us look at some of the things that happen as well as some things that must be avoided when applying equalization to some basic musical instruments and vocals.

Vocals

When using a mixer with simple bass and treble controls, only the low and high frequencies of the voice can be equalized. Often the low frequency sections of such equalizers will have little if any effect on female vocals because they are above the equalizer's effective frequency range. However, this low frequency control will usually prove quite effective on male vocals. One must be careful with the amount of treble correction that is used because the high frequency section of basic two knob equalizers are most effective in the 5 kHz region or above. Excessive equalization of vocals (male or female) in this frequency range will increase the amount of sibilance in the voice and will usually cause a "spitting" or "hissing" sound when the singer pronounces words with the letter "s". If a vocalist has an excessive amount of sibilance even when not using equalization, an equalizer can also cure this problem. Try cutting in the 4 kHz to 7 kHz region to reduce the undesired effect. However, you must not use too much cut in as it can sometimes cause a dramatic loss in the presence of the voice. A great deal of presence can be added to vocals with the use of mid-range equalization (boost) usually in the 1 kHz to 3 kHz region (depending upon the particular voice). Again, one must be careful because too much boost in this frequency range can cause excessive amounts of sibilance. The boosting of lower frequencies in the 500 Hz to 800 Hz frequency range will often add a warmth to the sound of a vocal. The boosting of frequency ranges that are either above or below the frequency range of the voice will rarely have any audible effect and will often cause the *unwanted* sounds of other instruments (which are in that frequency range) to be picked up by the vocal microphone.

Electric Bass

It is the normal tendency to boost the sound of the electric bass at very low frequencies (in the 30 Hz to 60 Hz range) to give it more "balls". When making recordings it is important to point out that during the disc cutting process, frequencies below 30 or 50 Hz are usually filtered out in an effort to cut the disc at a louder level and place more music (time) on the disc. For live stage sound, most loudspeaker systems will not produce a great deal of acoustic energy in the frequency region below 50 Hz. Usually a far greater effect can be obtained by boosting in the 100 Hz frequency range. Boosting low frequencies will usually provide a good effect; however, excessive amounts of boost in the low frequency region will often cause the electric bass to sound "muddy" or "boomy". Definition can also be added by boosting in the 800 Hz to 2 kHz region. This will tend to emphasize the percussive attacks of the strings. A little of this is often desirable.

Drums

Let us look at the drums in four separate parts: bass drum, snare drum, tom toms, and cymbals.

Bass Drum. For most recording or stage sound applications the microphone is usually placed a few inches in front of the drum. When equalizing the bass drum, many of the techniques as well as problem areas of the bass guitar apply. Do not boost at extreme low frequencies (30 Hz to 50 Hz). Usually better effects can be realized when boosting in the 100 Hz range. Additional definition can often be added when boosting in the 800 Hz to 2 kHz region. Still more definition can often be added by cutting at the extreme low frequencies (30 Hz to 50 Hz).

Snare Drum. The dominant energy from the snare drum is in the 1 kHz to 2 kHz region. This is the frequency region where the snare should be boosted. Boosting at frequencies in the 500 Hz to 800 Hz range may make the snare sound a little fatter, but beware of picking up leakage from the bass drum or tom toms in the snare drum microphone. A more crisp quality can be obtained by boosting at higher frequencies in the 2 kHz to 4 kHz region.

Tom Toms. Depending upon the toms and how they are tuned, one will usually find the most effective range for equalization in the 250 Hz to 2 kHz region. Some nice low frequency sounds can be obtained from the tom toms; however, it is important to maintain definition. Definition can usually be added by boosting in the 800 Hz to 2 kHz region.

Cymbals. The dominant energy for the cymbals lies in the 2 kHz to 5 kHz region. There is often a tendency to boost cymbals at frequencies in the 10 kHz region which make them sound paper thin. Far better results can usually be obtained by boosting in the frequency where the dominant energy lies.

There are basic rules and guidelines for all the other types of musical instruments. However, you can see from the instrument and vocal information already given that the guidelines are simple and basically revolve around working in the area of the fundamental frequencies. It does one no good to equalize at frequencies which a sound system will not adequately reproduce or which cannot be placed on a record.

ROOM EQUALIZATION (Room Voicing)

As we stated previously, it is not our intention to discuss room equalization in detail. This subject could be a book in itself. The material that follows will, however, offer some simple guidelines to help familiarize you with some important aspects of this topic.

Equalizers can be used between mixers and power amplifiers in environments such as recording studios, auditoriums, listening rooms, and theaters, to contour the overall frequency response of a speaker system within a room. In professional installations where a real-time analyzer (a piece of test equipment used to show the total energy present at all frequencies on an instantaneous basis) is available, the frequency response can be measured to determine what equalization will be needed to obtain a desirable frequency response. Even though the speaker system may produce an acceptable response alone, the room usually modifies the response and creates peaks and dips in various frequency ranges. A graphic equalizer can remove many of these peaks and dips by boosting and cutting in the appropriate frequency ranges. The 1/3 octave graphic equalizer is a popular choice for this application because of its large number of available frequencies.

In most cases where a real-time analyzer is not available, another analyzer can be used – the ear. One approach is to play recorded music you are familiar with through the system and adjust the equalizer for the desired sound. When the "EQ" is adjusted for the best sound, just be sure that no portion of the audio spectrum is given an extreme amount of boost or cut. Note as a special case that attempting to boost the output below the speaker system's low frequency capability will not produce much improvement and may cause damage to the woofer due to excessive excursion.

Another popular use of graphic, parametric, or paragraphic equalizers is to reduce feedback in sound reinforcement or stage monitoring systems. One method of achieving this is to make a sound check with all the "EQ" controls set flat. After a good mix is obtained, slowly increase the system gain until feedback or ringing begins to develop. When feedback occurs, it will often initially start in one portion of the frequency spectrum. The frequency range at which feedback will initially occur varies, depending upon the equipment used and the particular acoustical environment. The frequency at which the system is ringing, or beginning to feedback, may be reduced by lowering or cutting the appropriate frequency band of the equalizer. Which frequency band? It will be necessary to search for the correct one. The ringing will diminish when you adjust its corresponding frequency band – you will know when you find it. Now the overall sound level of the sound reinforcement system can be increased until feedback occurs again, when the same procedure is repeated. When this process is done several times, there will be a number of frequency ranges that have been "cut" (usually only by a few dB). This will now give the sound reinforcement or monitor system the ability to generate a higher sound level before reaching feedback. The operator must be careful because cutting the frequency response at these various frequencies places audible holes in the frequency spectrum. Sometimes after this procedure is done, things just don't sound right. It is often necessary to utilize smaller amounts of cut to enable the sound system to sound natural. This method of acoustic feedback suppression is a process of trial and error, and one of compromise (amount of additional gain before feedback versus the overall audible quality of the system).

DO NOT USE EQUALIZATION TO EXCESS

Equalizers give you the ability to change the frequency characteristics of instruments and vocals, but excessive amounts of equalization can make things sound very strange. This can be useful only when you desire an unnatural or freaky effect. When equalization is used in the boost mode, you are making certain frequency ranges louder, and this will reduce the amount of available headroom in your mixer or audio system, which can lead to distortion. This does not mean that using an equalizer will usually cause distortion, but that excessive equalization can in some instances cause problems. Equalizers, when used properly, are valuable tools providing that they are used with care and moderation.

Take the time to know the frequency content of the various musical instruments and voices. Spend time working and experimenting with your equalizer to become more familiar with it and the effects that can be obtained. Learn by trial and error. You are bound to make many mistakes – we all have! Review the information in this PA Bible addition carefully and become familiar with it. Blend into this the information on sound systems and their components contained in the original PA Bible and its previous additions for a more thorough understanding of the total system. Couple that knowledge with experience and a few goofs on the way and you will soon be mastering the art of equalization. Happy Equalizing!

SPECIAL NOTE TO THE READER

The E-V "PA Bible" and this addition have been prepared to help you solve your PA problems. Let us know if you have any other areas in mind for us to tackle.

E-V "PA Bible"
Electro-Voice, Inc.
600 Cecil Street
Buchanan, Michigan 49107

Electro-Voice®
600 Cecil Street, Buchanan, Michigan 49107
8234 Doe Avenue, Visalia, California 93277
Electro-Voice Div., 345 Herbert Street, Gananoque, Ontario • Electro-Voice, S.A., Romerstrasse 3, 2560 Nidau, Switzerland