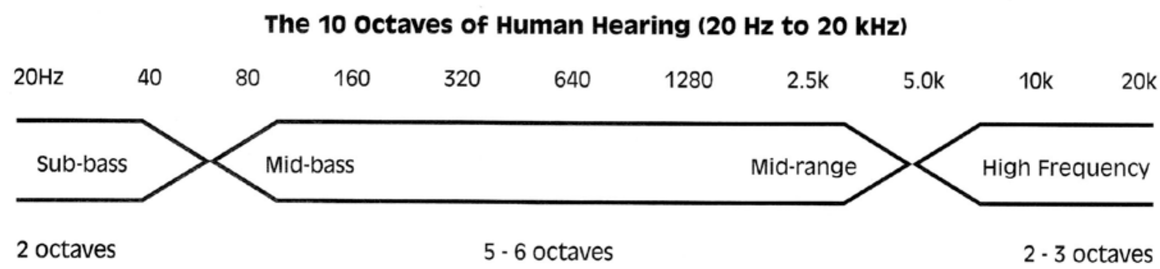
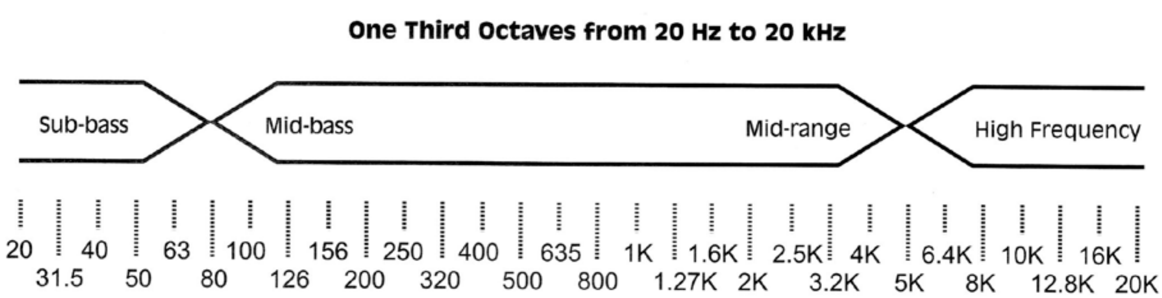
Introduction to Equalization

Tools Needed: Real Time Analyzer, Pink noise audio source

The first thing we need to understand is that everything we hear whether it is musical instruments, a person's voice or the constant howling of the cat next door is comprised of sounds that fall within the 10 octaves of frequencies that we as human beings can hear. An octave is simply a halving or doubling of a frequency from a given starting point, and for most of us that starting point is 20Hz (the lowest frequency we can hear). An octave up from 20Hz would be 40Hz. The next octave up is 80Hz, then 160Hz and so on until we reach the limit of our hearing which tops out at 20kHz (20 thousand Hz, or the highest frequency we can hear). Everything we can hear falls into this 20Hz to 20kHz range.



OK, so now we know what an octave is and what the 10 octaves of human hearing range are. What is 1/3 octave? We… it is simply the same 20Hz – 20kHz range broken into 1/3 octave slices. Calculating 1/3 octave intervals is pretty easy too. You simply start at 20Hz and multiply it by 1.26 to get 25.2Hz. We round this to 25Hz. So 1/3 octave up from 20Hz is 25Hz. The next step up from 25Hz would be 25 x 1.26 or 31.5Hz. The next 1/3 octave step is 31.5 x 1.26 or 39.69Hz. Like above, that is rounded to 40Hz. This goes on and on all the way up to 20kHz.



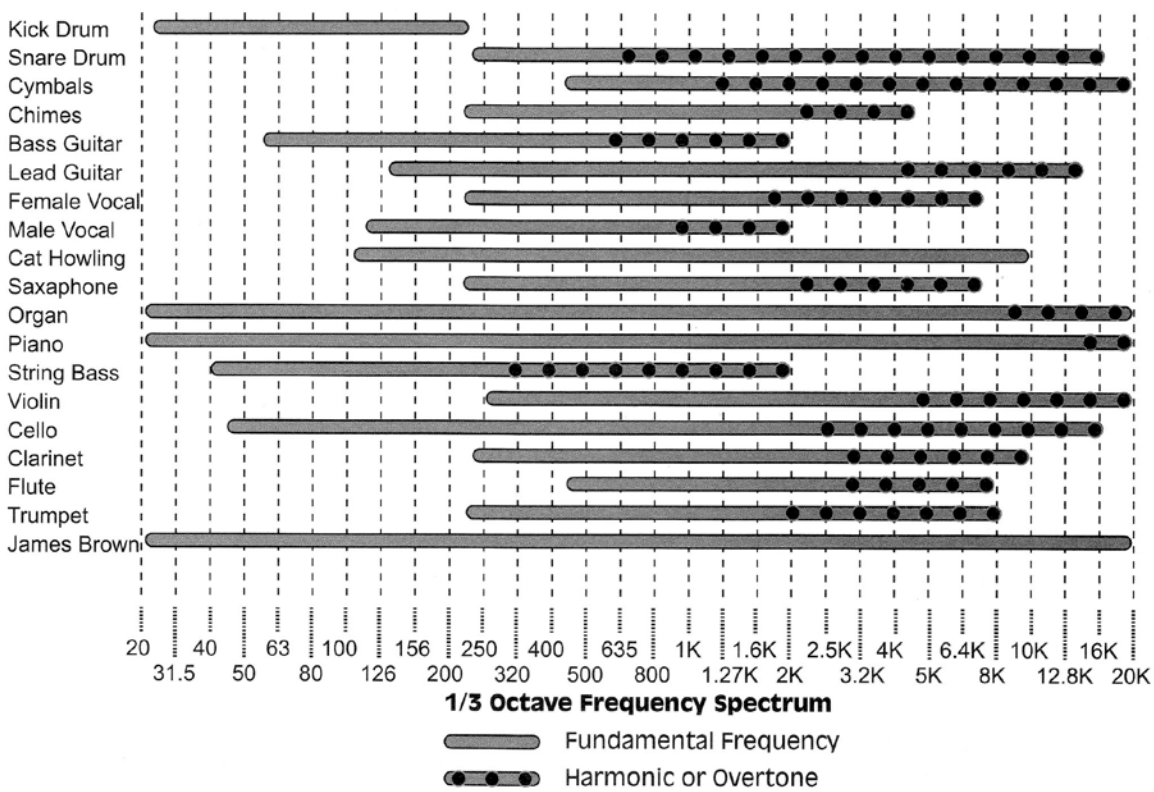
Not fun math notice:

Right now you must be saying to yourself just where do we get 1.26? Isn't .33 equal to 1/3? Just trust us when we say to use 1.26… we are skipping a bunch of difficult math. We hear in a logarithmic scale, not linear, and 1.26 breaks the logarithmic scale up into 1/3 slices. OK? Good. Let's move on…

So if our hearing works within these 10 octaves, where does 1/3 octave come into play? Why 30 bands? It has been determined that 3dB changes between 1/3 octaves are the smallest changes the human ear can easily detect.

A 1/3 octave is designed for tailoring your sound system to better fit your listening environment, or to just make it sound like you want it to sound. Experimentation has shown that the way the human ear sums energy in the Critical Bands to determine the loudness of a sound are about 1/3 octave apart. Because of this, one third octave spacing is all that is required to tune a system within the capabilities of the average human ear. You could use an equalizer with tighter spacing (like a 1/6th octave), but this would only present you with twice as many controls and no audibly better result.

The chart below gives you a good idea where some of the musical instruments and voices operate within the 1/3 octave scale. The fundamental frequencies are the primary sounds the instrument makes when played. The harmonics or overtones are multiples of the fundamental sound. Think of it as striking a hollow drum. When you hit the drum it makes a distinct sound, but there are extra sounds that reverberate from the original strike. These extra sounds are harmonics. These harmonics plus the fundamental give every instrument, voice or sound its own unique sound.



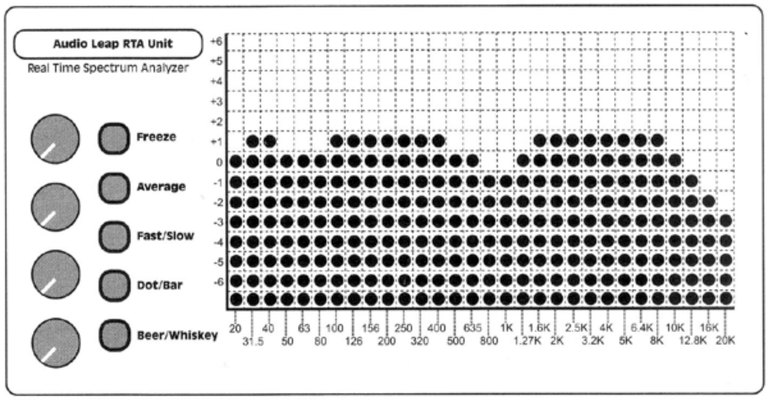
The above chart gives you an idea where popular instruments and voices are located in the audible spectrum. Knowing this can help give you some direction when tuning your vehicle to that certain sound you're after or adding a little definition and character to a particular instrument.

The chart below breaks the frequency ranges down into smaller groups and gives you a general idea of how each range effects the musical spectrum. The last column on the right gives you an idea of what can happen if you apply too much equalization to that area.

Equalization is like adding spice to your food. Not enough and the food tastes bland… too much and you're reaching for the water. The right amount of equalization will really make your system shine.

Frequency Range	Affected Area	Results Of Excessive Boost
16 Hz - 60 Hz	Sense of power, music is felt more than heard.	Makes music sound muddy.
60 Hz - 250 Hz	Fundamentals of the rhythmic section. Equalizing here can change the musical balance making it fat or thin.	Makes music sound boomy.
250 Hz - 2000 Hz	Low order harmonics of most musical instruments that are horn-like. Listening fatigue may result if improperly equalized.	Gives telephone like quality to the music. Can make the music sound tinny.
2 kHz - 4 kHz	Speech recognition.	Listening Fatigue. Will add a lisping quality to voices. "M", "V" & "B" will become vague.
4 kHz - 6 kHz	Affects clarity and definition of voices and instruments. The music will seem closer to the listener with proper setting.	Sibilance on vocals (harshness). Adding boost at 5 kHz will make the music seem louder.
6 kHz - 20 kHz	Brilliance and clarity of sounds. Gives air and pressence to the music.	Sibilance and/or harshness on voices

To properly adjust your 1/3 octave equalizer, it is highly recommended that you, someone you know, or your local dealer have and be familiar with the use of a 1/3 octave RTA (Real Time Analyzer). The RTA shows you where the peaks and dips in your systems response curve are located and dial in the proper amount of boost or cut at the correct frequencies to get a smooth overall system response. The RTA should not be the only source of input to tell you what needs to be tweaked… you must also listen.



There can be times where no matter how good it looks on the RTA display, it simply sounds bad to the ear. By the same token, a curve that may show some uneven response may actually sound pleasing. You always want to start with the RTA and look for major peaks and valleys. Fix these first and then listen. Do this back and forth until you get a response that is smooth as possible and sounds realistic Here are 5 basic pointers to keep in mind as you start your quest to EQ perfection:

1. Your goal is a smooth curve with no more than 3dB difference between bands. Flat lines, happy faces or ski slopes are not necessarily the goal, unless you are into that sort of thing.
2. Always cut first, boost last and keep your boosting to as little as needed to get the desired results. For every 3dB of boost you are asking your amp to double its power output at that frequency. If you notice that most of your frequencies are boosted, simply lower all frequencies equally to reduce the overall level. Remember… cut before boost…
3. Equalization does not change the basics. A properly adjusted equalizer is not a band aid for poor components or installations. Address these issues first… EQ last.
4. If you find certain frequency valleys that do not respond from boosting, you may have some cancellation at that frequency due to speaker placement, speaker phasing, crossover phasing or simple vehicle acoustics. If this happens, address these issues separately.
5. Your ears are always right. No matter how good or bad it looks on the RTA, if it sounds bad… it sounds bad. Period. Let the RTA guide you and your ears tell you if it’s right.

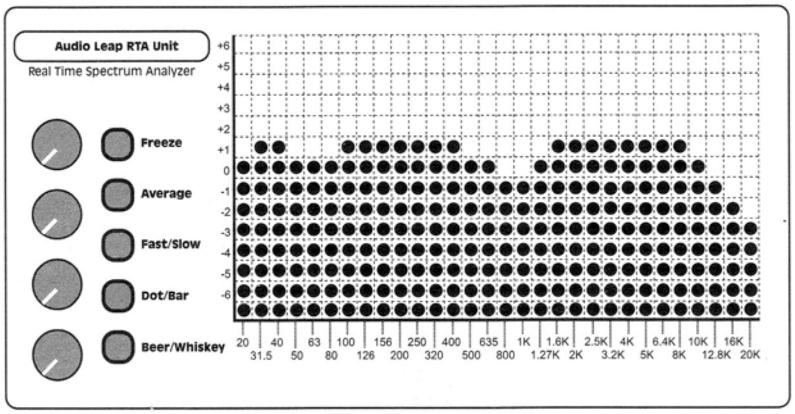
Let’s get started…

You’ll need a source of pink noise. That could be a CD, MP3, etc. The pink noise should be played through the head unit (usually the first component in the audio system). Turn on the audio system and set the volume of the pink noise to a good working volume. Not too loud and not too soft.

Now for the RTA…

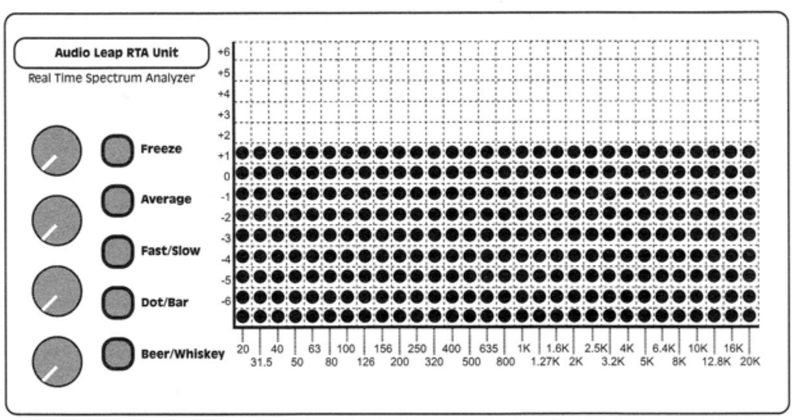
With the SPL set and the pink noise continuously playing through your system, put the RTA into analyzer mode. Set the speed to medium or slow and the resolution to 3dB/step. You will now see a graphical representation of how your system is working at playing back the pink noise test signal. Figure 1 gives you an idea of what you should be seeing, except yours should be moving up and down at the various frequencies.

Fig. 1



The pink noise that you are playing through your system is a recording of equal energy at all octaves being played at the same time. If you were to look at it as a pure signal; before it went through all your amplifiers, crossovers and speakers, it would look like the display in figure 2.

Fig. 2



How is this useful? Knowing that the signal coming from the audio source before it goes through your system is supposed to look like a flat line gives you a known reference. Looking at it with a microphone after it has gone through your head unit, equalizers, crossovers and finally your speakers gives you an idea of how the signal is being affected by these components.

You also see the effect that speaker placement and phasing has on what you hear as well as how the car itself is affecting the signal.

The end result is the ability to look at how everything is affecting the sound you hear in your car. Does this mean we should equalize the car back to a flat line? Definitely not. Car audio competitors will shoot for the flat line so they can get a perfect "score" in the RTA judging section of a contest, but for listening, a flat line just sounds bad.

So if I am playing a source wich is essentially a flat line and you don't want me to equalize it back to a flat line, just what am I supposed to do? The key to using the RTA and pink noise is to look for major problems with the response curve and smooth them out. Remember from the introduction 3dB changes between 1/3 octave bands was the smallest change the human ear can detect? Well that is what we are trying to do here, simply keep each 1/3 octave band within 3dB of the other as we go from 20Hz to 20kHz.

The overall shape of the curve is not as important as keeping each band within 3dB of those around it. You may like a real bass heavy sound while your friend does not. So you can both have smooth response curves that look different because they are based on how you like it to sound. (Figure 1 and 2)

Fig. 1 your response curve

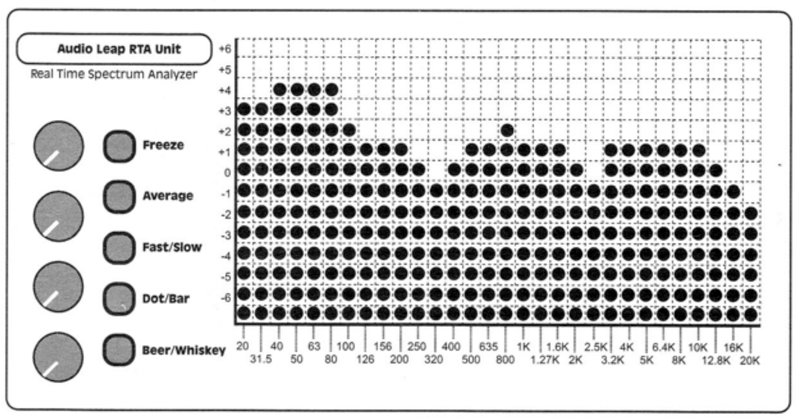
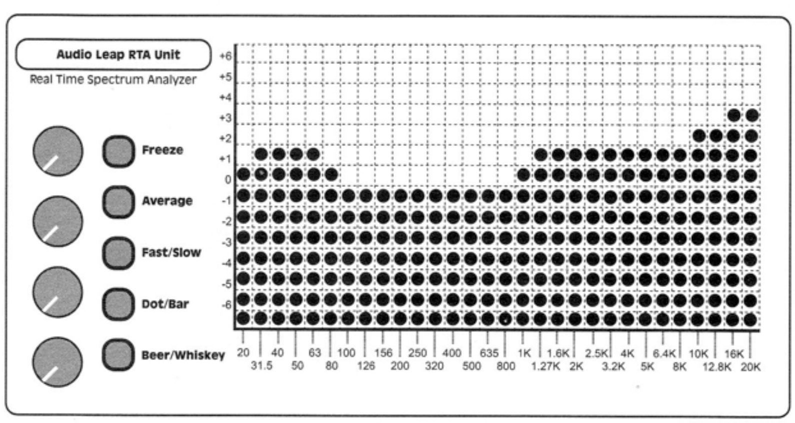
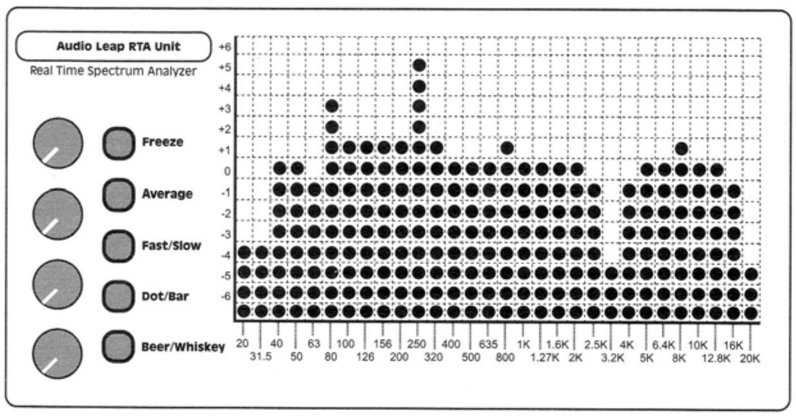


Fig. 2 your friend's response curve



Neither curve is more correct; it just depends on how you like the sound. The one thing you do notice is that each 1/3 octave band is within 3dB of the next band.

Fig. 3



So what does a bad curve look like? Check out figure 3. Notice how 31.5Hz is more than 4dB down from 40Hz. See where 80Hz is more than 3dB above both 63Hz and 100Hz? How about thet nasty spike at 250Hz? These are problem areas that need to be corrected.

Your first step should always be to equalize out the peaks by cutting (reducing the gain) of the controls at or near those frequencies. Next you would try to bring up the valleys by boosting in those areas (or cutting around them) Your end result is to keep the sound you like but smooth out the overall response so there is no more than a 3dB variation between bands.

So if you start with figure 3 you want to end up more like figure 1 or 2. Not necessarily the same overall curve, but smooth transitions from band to band.

If, after doing all your equalization and level adjustments you feel that your system lacks “bite”, even with your source unit turned up to 90% of its output potential, then the gain settings on your amplifier may be turned up slightly. Keep in mind that the gain settings on any amplifier are for level matching only, they do not increase the power output of your amplifier. The lowest gain setting that will allow your amplifier to make full power is always best for sound quality, lowest system noise and reliability.

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