CICADA AUDIO WHITE PAPER (ARTICLE 1)

Correctly Adjusting Gain and Crossover Controls on your Amplifiers/Processors

By Larry Frederick and Friends

Many retailers/installers/consumers have always had “issues” with adjusting gain. When is a little too much and when is too much too little? Do I turn the input gain all the way UP, or all the way DOWN? A common example of misguided information is the consumer comes back to you after a system has been installed and complains that their “buddy” – or “local audio expert” has noticed that you did not give them all the amplifier power that they bought! Inevitably the customer’s buddy says that because you have the gain settings tuned WAY down, the amplifier is NOT delivering full power!! Their rationale is that the installer CHEATED them on the power they bought!!!! The installer set gain at less than half (there is NO such thing as half gain, by the way)…therefore it must be only putting out less than half power!! To answer those questions and many more….read on!!

THERE IS “NO SUCH THING” AS 1/2 GAIN, 3/4 GAIN. ETC.
MEANS NOTHING WHEN SETTING UP INPUT SETTINGS!!!!!

Half gain or 3/4 gain settings DOES NOT mean that the amplifier is only putting out 1/2 power, or 3/4 power. Totally ridiculous logic. NOT the way it works!!!. If the amplifier is 500 watts, its 500 watts with the gain at minimum or maximum. PERIOD !. Input gains settings have NOTHING to do with it (OK...a little...But read on). Input VOLTAGE has EVERYTHING to do with where gain is set!!! So if you have a low voltage out HU and the gain is set to minimum (all the way down counter-clockwise) then YES you are going to make very little power.

I’ve taken the liberty to “borrow” from our “Down Under” fellow 12 volt guys (read Australia here!) and used something they wrote about correctly setting gains from a couple years ago and added some of my own additional information (see credits at the end of the article) Hey…Why reinvent the wheel?? In addition to their informative article, periodically you’ll see my “2 cents worth” thrown in ! (Quite a bit actually)

To that end let’s get gain setting done....Correctly!!!

Abbreviations used in this article:

- EQ = Equalizer
- HP = Highpass
- HU = Headunit
- LP = Lowpass
- RMS = Root Mean Square
- W = Watts (Electrical Power)

NOTE: If you want to “cut to the chase” and just set your damn gains…go to page 12 and there is where Step by Step instructions are.. Near the bottom of this “White Paper”

BUT WE HIGHLY RECOMMEND THAT YOU READ THE WHOLE ARTICLE SO YOU REALLY UNDERSTAND WHAT IS GOING ON!

KNOWLEDGE IS POWER!!! THE MORE YOU KNOW..THE MORE YOU KNOW YOU DONT KNOW ENOUGH!!

So lets get started ..in the beginning - about the time the earth was cooling - I was a small child in Burbank California…oh…maybe that’s too far back…?

WHAT IS A "GAIN" CONTROL - REALLY?

The gain control on ANY amplifier (or Processor) is NOT a volume control. Say it out loud! Turning the gain up higher and higher does not produce higher or 'full-power' output. If an amp produces a maximum of 100 watts (RMS) per channel, increasing the gain will not yield more than this. At 100 w/channel and assuming two channels, it's a 200 watt total amplifier and – theoretically – a 400 watt mono 4 ohm amplifier if it's run in a "bridged" mode. That's it. No more. Turning input gain up (or down) does not make the amp more powerful. If it's a 200 watt amp …it's 200 watts…PERIOD!

Gain has NOTHING to do with adding (or making) more POWER.

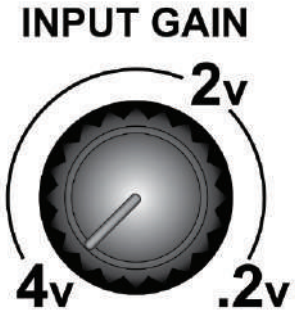
Better to think of the gain as a 'sensitivity' setting: the higher the gain, the more sensitive the amp is to the signal fed into it. This means that a headunit (HU) having more preamp output voltage (say 4 volts) will have an amplifier input setting lower than a low voltage preamp output HU (1 volt for example). This does not make the amplifier more powerful by turning the input gain up. In fact turning input gain "UP" causes more system noise..Or HISS.

First…we need to understand how an input gain adjustment works…look at the example to the right of a typical input gain on an amplifier (or signal processor, makes no difference).

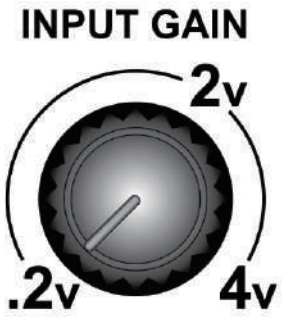
For purposes of discussion, let's say we have a standard amplifier that can take from 0.2 volts (200 mV) to 4 volts of input signal. Look at this rotary gain control illustration again.

Now the question is which END is the minimum setting and which END is the maximum setting??? In other words which is the 0.2 v setting and which is the 4 volt setting?? What do YOU think it is???? This is the most basic fundamental concept of gain, and the question which 90% of those who are quizzed get WRONG!!

So what do YOU THINK??



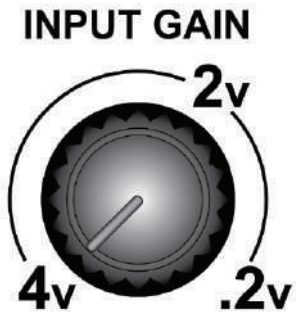
OR.....



(OK.. you;ve got a 50/50 chance here!@!! Guess!!!)

The correct answer is shown on the next page

THE CORRECT ANSWER IS: Not what you thought? Right?? Remember that the input gain control is a potentiometer (pot), which is nothing more than a variable resistor. At the "minimum setting" – fully counter-clockwise, it has the MOST resistance, and at the "maximum setting" – fully clockwise, it has the LEAST resistance. The input gain control is just an attenuator. Think of it like a varible brightness light switch/dimmer. Now...think about it how that works? How does a light dim? Hmmm?? 120 volt light bulb and when you slide the dimmer it lowers in brightness? Maybe becase the voltage is going down? Less voltage , light dims! Duh!!! The "dimmer" is an attenuator. Just like a "Gain" control. Its just an attenuates the input AC voltage (the signal from the HU).



As an example, consider three gain settings: A, B, C.

A is 'low', B is 'medium' and C is 'high'. The lowest possible setting would be fully counter-clockwise (the A setting) and highest would be fully clockwise (where the gain control is a 'knob' or pot) for the C setting.

Now let us say the HU is delivering a 2V signal via the preouts (typically the RCA outputs) at it's maximum usable volume position BEFORE signal clipping occurs. With the gain at B, the amp may be producing 100WRMS per channel. If the gain is now changed to A (4V setting), the amp is less sensitive; in order to produce the 100 WRMS as before, the HU must now deliver a higher voltage signal, say 4V. Setting the gain to C, the amp becomes much more sensitive; it now may require only a 0.2V signal to produce 100 WRMS.

The whole purpose of gain setting is to match the audio signal voltage output of a given headunit with a given amplifier. You see, unlike some standardized home audio equipment that provides a known signal level from one component to another, car audio headunits and amplifiers can have a very wide range of possibilities of audio output signal levels, both on preamp (RCA) signals and powered (speaker level) signals. The input gain control allows you to essentially match one piece of equipment to the other for ideal performance.

A HU with a higher voltage signal will require a low gain/sensitivity setting; if the HU only produces a low voltage signal, the amp would need to be more sensitive (read –have more GAIN) to produce the same power. The input "gain structure" of different manufacturer's amps is…well different. ALSO....Gain is NOT going to be the same with all amplifier manufacturers, and not even necessarily with different lines of amplifiers from the same manufacturer.

Basically having the gains set TOO high causes all sorts of issues. If input clipping occurs (by having the input gains CRANKED!!), then the system distorts quickly, background "hiss" goes up (tell tale sign that gains are set TOO high) and the amplifier runs really HOT really FAST. But if there are mutiple devices in the signal path (LOC, DSP, EQ, Electronic Crossver, etc) then ....WHICH one is clipping ???

What do the voltage markings on the gain setting mean?

Some gain controls have markings with ‘voltage’ to use as a guide. These voltage settings suggest to you what audio signal input voltage is required to make the amp produce full power. You’ll note that with a high gain/sensitivity setting, the marking may read 0.5V; this makes sense because the amp needs to be more sensitive to respond to a low voltage signal in order to produce full power. Whereas a low gain setting may have a marking of 4V; with such a high input voltage, the amp needs to be far less sensitive to produce full power. Some amplifiers may also have a “range” switch to accommodate signal levels from either preamp level or speaker level inputs. Typically speaker level inputs are higher voltage, but may also clip sooner depending on what IC “chip” amplifier is used to drive the output. In general, preamp level signals go through fewer components in the headunit and are often recommended for connecting to the amplifier.

What RCA preout voltage does my HU produce?

Unless you have sophisticated measuring equipment like an oscilloscope, you will not know what voltage the RCA signal is from you HU, at least not without knowing where it begins to distort.

Handheld Oscilloscope

The advertised voltage found in the specifications on your HU refers to the output signal under test bench conditions: usually by playing a constant signal like a test tone (sine wave) at a fixed frequency and it does not always mean that the advertised specification for output voltage is the same amount of output voltage that’s “clean” and free of distortion. Test tones are obviously very different to conditions to playing actual music. Music is very dynamic, meaning it is constantly changing between loud and soft. Whereas the test tone is always the same, varying only in amplitude (which is the “volume” of the signal, measured in volts AC.

It is important to realize that the RCA preout signal voltage, when playing music is far lower than if playing a test tone at the same position of the volume knob. Therefore, while a HU may feature '4V preouts', when you play music the 'average' voltage may in fact never reach beyond 1~1.3V…or lower. Sure, it may peak as high as 4V, but never reach that level in a sustained manner, at least under music conditions.

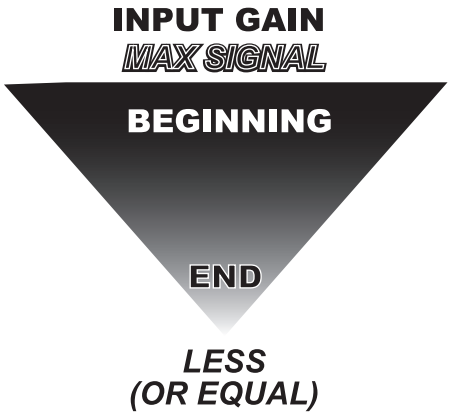
Of course, these maximum "advertised" output signal voltages are only achieved when the HU volume is turned up to full (wherever that may be!). Using a low volume setting, as you would for normal listening, the signal voltage is far less again.

The implication is that the gain setting on the amplifier must be much higher than predicted. You should expect a 5 dB to 10 dB 'overlap' in voltage.

For example, a HU claiming '4V preout' signals will only produce an average of 1 to 1.3V when playing music and at full volume, which is 10dB down and less than the predicted 4V output. The gain setting remains true however; that is, if you set the gain to the '1V' marking, the amp will produce full power when the HU delivers 1V with an oscilloscope measuring this with a 1,000 Hz sine-wave. Or 2 volts, or 3 volts and so on and so forth.

Simply remember the Gain Pyramid –

Ideally, the preference is to have ALL the gain at the beginning of the signal chain and the least gain necessary at the end. A 4 volt preamp output HU is WAY better than a 2 volt preout HU!!). Amplifier gains set at absolute minimum are preferred because the overall result is a lower noise floor of the entire audio system!! This means less audible hiss when the amplifier gains are minimized AND optimized. Subwoofer amplifier gains can be somewhat higher because of ambient noise floor (road noise, etc) and the fact that subwoofers generally are positioned further from the listener; hence they make it harder to hear the audible hiss of the slight increase of gain.



Why set the gains properly?There are several reasons to set the gain control properly:

1. The wider the range over which you can use the volume control on the HU, the finer the control you have. There's no point having the amps reach full power with only 30% on the headunit dial where every little step on the HU is fully tuned clockwise (all the way up!!) (100%) or as close to 100% as possible, the difference being where the signal distorts if it does so before the headunit reaches full volume. You know the gains are set incorrectly when the system gets very loud…VERY quickly and the master volume control is not near its limit. As an example, if the HU readout for volume goes to 35 as its maximum volume output and at a volume setting of 10 the system is VERY loud, 99% chance that the gains on the amplifiers (or signal processors in-between) are set too high (meaning – incorrectly!)

2. To avoid overpowering speakers. Every speaker has a power handling limit; if it is fed a continuous amount of power beyond this, it will be at risk of having the voice coil overheated and permanently damaged. Gain settings can be used to limit the amount of power being delivered to within safe operating levels. ANY voice coil that is “blackened” or burned has been thru intensive ABUSE. This is NOT a flaw of the speaker, or a design issue. It is simply ABUSE!!!! Whomever is turning the volume control just doesn”t care!! They think it just SHOULD play louder becasue “Hey...I paid all this money!!!” DAMN logic and physics!!!! I WANT it to play louder!!!!! Just cause!!! (Pixie and Fairy Dust!)

3. To avoid ‘clipping’ the amplifier. Clipping occurs when an amplifier is pushed beyond its design limits; this limit is the maximum clean output power the amp can reliably produce. Beyond this, the output signal becomes highly distorted, and is referred to as being ‘clipped’. Clipping is very audible with test tones and difficult to mistake. Although it’s a bit less obvious to identify clipping with the varying nature of music signals, by the time you DO hear clipping with the music signal it’s going to be severely distorted! If the gain is set too high, the amplifier will reach full power when the volume control has not reached full; if the volume control is turned up higher, the amplifier is now pushed beyond its design limits into clipping (which means it’s introducing a distorted signal into the audio path). By reducing the gain setting, the amplifier will never reach clipping despite the volume control being turned up full. Note that clipping does not necessarily mean the speakers will be overpowered; therefore it is not always dangerous for the speakers (see later).

4. To achieve a nicely balanced system between front and rear speakers, and the subwoofer, their respective levels need to be matched. Using correct gain setting procedures is a useful means to achieve this.

What happens if the gain is set too low?

If the gains are set too low, the amp will not be sensitive enough to reach full power. For example, if the gain is set where the amp requires an input signal of 3V to produce full power but the HU only delivers 2V even at full volume, the amp will never reach full power. This is wasting the potential of the amplifier.
However, this may still be required if you are to achieve a better balanced system, or more importantly, to avoid overpowering the speakers or subwoofer.

As such, a ‘low’ gain setting can be used to cap power output from the amplifier, or match it with the outputs of other amplifier channels in the system. It’s much better to back off the gain of the louder amplifier (or channel) then to try and take an amplifier channel that’s lower in volume and subsequently dial up the gain to try and match. What happens? Well you already know what could happen, and it’s unlikely the results of added hiss, possible clipping, and overpowering can really help things. Remember it’s better to cut gain from the louder amplifier..

What happens if the gain is set too high?

This has been discussed above. The problems encountered include the risk of overpowering speakers and causing clipping, as well as excessive system “Hiss”. Excessive system hiss is increasing the noise floor, which is the lowest audible noise the audio system makes when there’s no signal passing through. When gain is excessively high and the volume is very low, audio systems with a high noise floor have a real apparent hiss. In other words if your system “hisses” and it is very obvious, go back and check you gain adjustments again. Chances are you’ve introduced too much gain in at least one stage of the signal path. Either at the amp or at the processor in front of it.

What is distortion and overpowering speakers and subwoofers?

In audio, distortion is a music signal (electrical or acoustic) that is less than 100% identical from the original. Even though an amplifier’s job is to “amplify” the signal, it’s only to increase the signal voltage, not to “color” it in any way. Where the CD recording is the ‘original’, distortion may occur when this data is converted from digital to analog, as it passes through the controls (preamp) of the HU, along the RCA signal cables, into the amplifier, out to the speakers and in the reproduction by the speakers themselves. Some is audible and this should always be considered ‘bad’, if not only to our ears, but also to the components. Very small amounts of distortion are common as the equipment operates and does its thing, but you want to avoid adding in severe distortion by incorrect adjustments of input gain levels.

Important forms of distortion to be aware of include:

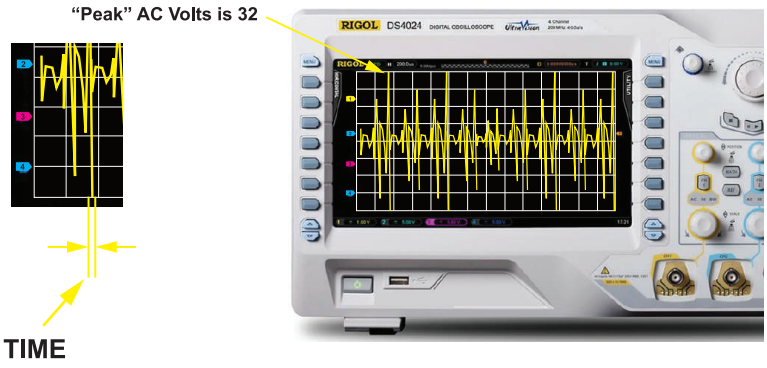
1. Over-excursion of the cones of speakers and subwoofers from being pushed beyond their physical limits. This typically occurs when small speakers (e.g. 4 to 7” diameter) that are part of the front-speaker setup are fed too much bass, especially when delivered a ‘full range’ signal. By using a HP filter to remove bass, it will greatly improve the power handling of the speaker and avoid over-excursion.

2. Clipping of the amplifier. Discussed above, clipping occurs when the amplifier is pushed beyond its design limits of producing ‘clean’ power and the output signal becomes distorted. This transition is typically sudden and harsh, but some amps have soft clipping, which is far less noticeable. Other amplifiers feature a clipping warning system, which is commonly an LED warning light.

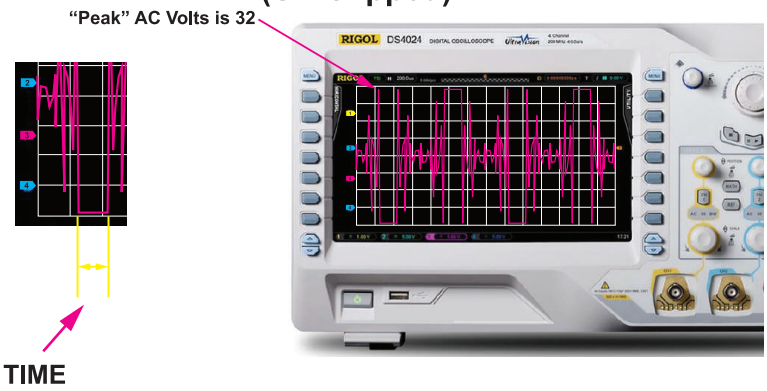
Overpowering of speakers occurs when either they are pushed to over-excursion or the power being delivered exceeds their power handling. Every speaker and subwoofer will have a power handling designation specified by the manufacturer, and usually marked onto the speaker itself. You should always refer to the ‘RMS’ power handling specifications for the speaker, not necessarily the peak, MAX, or “if lightning strikes”inflated ratings.
It is possible to cause over-excursion without exceeding power handling. For example, a 6” speaker may have a power handling of 50WRMS, but if fed a signal with Subbass (below the Fs or free air resonance of the speaker) it may over-excurt and distort with only 30WRMS of power. Usually a speaker or subwoofer audibly distorts if it is overpowered. This is a warning to back off or risk permanent damage! Clipping can cause overpowering and is therefore dangerous for speakers. It is a common cause for burning out voice coils.

Oscilloscope with unClipped and Clipped waveform

SCOPE LOOKING AT AC WAVEFORM OF MUSIC (Un-Clipped)



SCOPE LOOKING AT AC WAVEFORM OF MUSIC (Un-Clipped)



A clipped audio signal is typically far more powerful than a clean, unclipped audio signal, quickly reaching double the power of the clean signal. It is because of this rapid transition that people often misperceive the actual issue. The output of the HU clipping can cause the amplifier to clip LONG before full power output of the amplifier. Setting gains properly can avoid clipping! ***You need to know WHERE your HU clips at !***

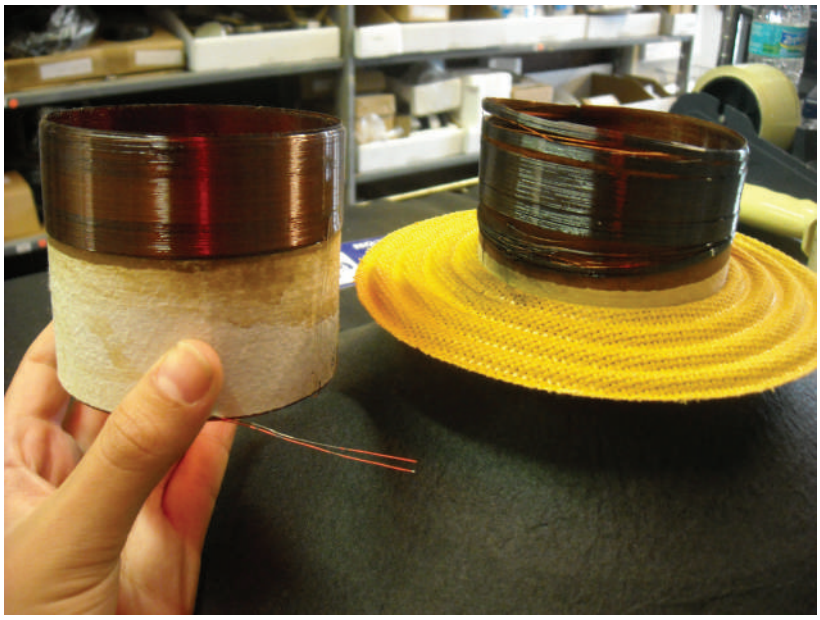
Note that clipping, per se, is not dangerous for the speaker. It is the actual electrical power of the signal (representing a value of heat) that causes the overpowering. For example, an amplifier may produce only 100WRMS of power, beyond which it will clip. If clipped, the signal may reach around 200WRMS. However, if the subwoofer it drives has a power handling rating of 300WRMS, it will not be overpowered or at risk of seriously overheating. Therefore, the subwoofer will happily reproduce a clipped signal of 200WRMS all day long; it will just sound terrible and the amplifier may overheat from delivering that clipped signal! But doing this for long periods of time is VERY destructive (see the voice coil below)

So understand that clipping is a sign that the amp is being pushed beyond its limits; that the onset of clipping causes a rapid increase in power output, albeit highly distorted; clipping does not necessarily mean the speaker or subwoofer will be overpowered. The result of clipping is pretty obvious. For example burned voice coils of speakers (typically subwoofers) But midbass and tweeters as well

BURNT Voice Coil

This is NOT caused by a “design” error, this is caused by abuse!! Period. It takes a LOT of time and abuse to do this. It is NOT instantaneous damage!! Ya gotta work at this stuff!!!!! Think about it…high temperature copper wire wound on a high temperature voice coil former, bound with super high temperature glues. Come on!! You have to heat the voice coil UP really high..SUPER HOT…over and over again to get the coil (copper winding’s) to UN-glue from the former.

Below is a picture of a GOOD voice coil and a BURNT voice coil



How do I best utilize crossovers (filters)?

Crossovers are defined by the frequency at which they are set and how “fast” they filter out the unwanted audio signal (slope rate, also called “roll-off”), which is why another technical name for a crossover is simply “filter”. Depending upon the part of the audio frequency spectrum you wish to filter out, the crossover can be a lowpass (LP), high pass (HP) or even an band pass (which is a LP and HP combined) type of filter. Nearly all amplifiers include an active cross-over, and most are ‘variable’. This means you can adjust the frequency from the point at which the filter takes effect. Most slopes are fixed, commonly of 12dB/Octave effect. The higher the slope rate, the faster the filter. Meaning that 6 dB is relatively slow, 12 dB is faster 18dB is faster still and 24 dB is really fast (or steep, depending on how you want to look at it). Filter alignments can be either the most common – Linkwitz/Riley type or Butterworth type (or M derived or Bessel, or a number of other filter types).

These alignments have particular properties of how they create their slope “shape”, particularly where the relationship of two filters will be used near one another.

You should select the filter (frequency and slope) to suit the speakers and subwoofer, and also set them to achieve a nice blend between front, rear and subwoofer.

Generally speaking regarding the slope, the farther apart the speakers in a frequency range (such as a mid and tweeter component set), typically you would want a shallower slope (for example 6-12 dB per octave). Generally speaking regarding the frequency croosover frequency, if it is a small speaker (4 inch or 5 ¼ inch) and the crossover HP filter frequency should be set not to low (like 40-70 Hz for example) the speaker can be fed too much bass. This excess of bass in that small speaker will cause premature distortion from over-excursion and reduce its power handling.

Do you REALLY beileve that this 5.25" speaker can MOVE as far this 15 inch speaker?

(or go as low in frequency??)

REALLY??

Setting a HP crossover point for speakers too low then, may limit how loudly you can run the system because the speakers start "barking" at you. Other schools of thought have been that you should always start your crossover at least one octave above the speaker's Fs (Resonant frequency –or Fs)

The choice of frequency where the HP filter is set is a compromise: it is always better to have MORE midbass (70-150Hz range depending on the physical properties of the speaker itself) from the front speakers, asking too much of them will diminish their power handling. It may also 'muddy' their sound because they struggle to maintain the clarity of the higher frequencies whilst reproducing the midbass. Setting the HP filter slightly higher will improve power handling at the expense of midbass.

Setting LP filters is also a compromise. The subwoofer may also be able to reproduce midbass and as high as 200Hz quite well. However, these high frequencies beyond 100Hz are 'directional' to our ears: they can usually detect where in the car these frequencies are coming from. Having our ears detect midbass being reproduced from the rear of the car adversely affects the soundstage. You are aiming to have all the sound 'appear' to be from in front (like a concert). Subbass frequencies (well below 100Hz) are non-directional; therefore it works to have a subwoofer in the trunk because our ears cannot determine this. Note that if you can 'hear' a subwoofer's location, it will be because the subwoofer is either reproducing higher frequencies or there are rattles and vibrations that localize it. Time alignment can many times solve a lot of these subwoofer placement issues.

The actual ‘best’ setting for your setup will depend on many things, including quality of the speakers and their installation, acoustics in the car, and your tastes. However, as a rough guide, the HP can be set depending on the size of the speakers:

***6 to 7” speakers: 50-100Hz with 12dB/octave (or higher!) crossover slopes**

***5.25” speakers: 100-150Hz with 12dB/octave (or higher!) crossover slopes**

***4” speakers: 150-250Hz with 12dB/octave (or higher!) crossover slopes**

A steeper sloped filter will remove the bass more dramatically. Therefore you can afford to set the filter at a lower crossover frequency without delivering excessive low frequencies.

Most people recommend setting the LP filter near that of the HP for the front speakers. Note that filters are not a brick wall; they do not suddenly cut out frequencies below/above their setting. Therefore, any ‘underlap’ between filters does not leave a gap. An example of underlapping would include a HP setting of 90Hz and a LP of 70Hz. Underlapping is favored by most enthusiasts for best results. However, many systems sound best with equal settings or indeed overlapping crossovers where the subwoofer and front speakers share more of the frequencies around the overlapped range. Bottom line, IF you want the bass in your system to SOUND like it is in the front of the car (where it belongs) crossing over lower is one of the ways to do that. Just be smart about it!!

Setting the gains

You are now hopefully armed with some useful basic knowledge to help tune the car’s audio system to its best potential. The following is a recommendation for the steps required to properly set gain and crossover adjustments.

You want to perform these settings in an environment where loud music is not a nuisance.
In general, adjust front channel gains first, then rear (if applicable), and finally subwoofer. Then adjust the balance in sound between front, rear and sub, which may require turning the gains ‘down’ for some amps (e.g. sub amp or rear speaker amp).

You want to perform these settings in an environment where loud music is not a issue.

ALL of this “Gain” setting dicussions is dependent on WHAT system you have and the complexity of it. The more STUFF in the signal path the more difficult it can get. BUT all the things I have taught you up to this point still prevail!!
Remember ALL the gain at the beginng and LESS or EQUAL gain (voltage) at the end. Meaning if you put 4 volts in from the signal source (HU or whatever) you want 4 volts at the end or less, NOT more (as that will increase the noise floor)

For example lets say you have a simple system. 4 channel amplifier, Front and rear speakers (car, motorcycle, whatever) NO subwoofer. Now this is a ”piece of cake” from a gain setting standpoint! Not many “things” in the signal path. So Eazy Pezy.

1. Play music that is well-recorded and you are familiar with, featuring the entire frequency bandwidth from sub bass to treble.

2. Start with only the front speaker channels; disconnect all others by pulling out the RCA leads or disabling them via the HU (if applicable). If using a bridged 4-channel amplifier to provide 2 channels, you will need to set the gain for each side, left and right, separately.

3. Turn gain on the amplifer all the way down (full anticlockwise).

4. Turn HP filter “ON” if required (e.g. 70-120Hz for 6.5″ midbass or Co-Ax’s).

IF you are using this system “Full Range” then there is no need for HP filters

NOTE: Typical 6.5 inch speakers have Fs (resonant frequewncy) of 65Hz. So asking them to go full range is REALALY not a good idea! I would recommend a VERY low HP at like 40-60Hz just to protect you valuble speakers. But hey...its your funeral. You do YOU!!!

5. Turn off ‘loudness’ and set any EQ to flat.

6. Now play a high quality CD and turn the volume as high as it goes without distortion.

NOTE: Some HUs allow 100% volume without distortion via the RCA preout; others go only as high as ~90% before distortion; set it just below any distortion. Using a LIUMY LM2020 scope (or any scope!) and a 1,000Hz “0” Bits High sinewave (AutoSound 2000 CD104 or get the 1Khz off the net) below is what is should look like unclipped (left side of waveform shown below, then clipped – which is no good, and the right side of the same waveform shown! Pretty hard clip!!) Waveform Not Clipping (up to 2) and progressively more clipping (2-10)

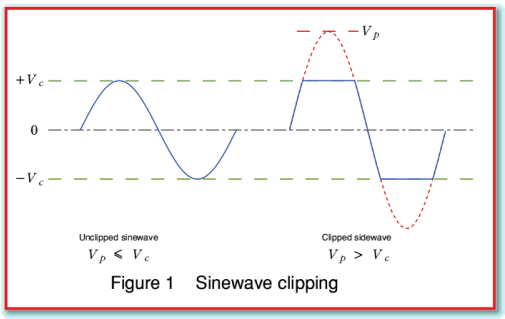


Figure 1 Sinewave clipping

7.Gradually turn the volume up on your HU: keep going until you now hear distortion (the “clipped” waveform on the right side of the above sinewave waveform. Or see it with your scope

NOTE: I DO NOT recommend that you set gains with a scope! Period. Don’t know how many scopes you have (I have 5!) and... I use mine pretty much everyday….BUT not to set gain!!!!

It is good to know where your HU clips at…BUT that is tested with a 1,000Hz - O bits Sinewave. Which NEVER happens in music EVER. The 1,000Hz sinewave I mean....So it AIN'T real!!!

Music is "dynamic" and typically has a "Creast Factor" of +10-20dB

So IF you set up a system with a scope and a 1,000Hz Sinewave ..you'll notice the system NEVER Clips…BUT has no energy (some installers call it "the NO-Balls Syndrome" I always say…I don't have a "Ball-O-Meter" so what the hell does that mean? In actuallity it means the system has NO dynamic headroom. Because you set the gains to low.

Nice try…NO CIGAR on this gain setup!!! But again....there are lots of YouTube videos telling people to use scopes and DD1+'s etc. So like I say....you do you. Dont listen to the guy who has developed 1,000's of amplifiers over 30 yrs, tuned 10's of thousands of world class SQ cars all over the world. What the hell do I know.? Yeah.....

8.Back to where we were. With the HU volume all the way (or really close) listen for any audible distortion. Obviously this should be considered 'bad',. But since you have the input gains on the 4 channel amplifier all the way down (counter clockwise) there should be NO distortion. It may be loud. But NOT clipped.

9. Continue playing the dynamic music ...Turn the gain up a little. Then more gain until your front speakers "distorts" or bottom out (to much low bass casuing over excursion) Therotically you have already set the HP filter (yeah...casue you listen!! Right) Assuming you have. Now would be the time to increase (raise) the HP crossover frequency up to elimainate the bottoming out or distortion your hearing REMEMBER that we are trying to get maximum output (volume), WITHOUT killing or burning up your expensive speakers!!! So this is a "dance". Basically go as low as you can go on the crossover before the drivers "bottom out" (over excursion)

10. Once the front channel is done, turn the HU volume down to a normal listening level. Now adjust the rear speakers to match up in level to the front speakers (by ear!!) After doing that...You will want to crank the system up again now and see if the rear speakers distort OR bottom out as you may have 6 X 9's in the rear or 8" speakers which have typical lower Fs compared to 6.5" speakers. So the HP filter you use may be different (more than likely...just saying!!)

NOTE: Sometimes the rear speakers wont distort, or over excurt. That is good. BUT I still recommend running a HP filter on ALL Coax speakers (especially Co Ax horns!) Just to protect them.,.,.from YOU and the music you listen too (I've heard what you listen too!!!)

So now the Front and Rear gains and HP filters are set properly. They are at a level where you will have maximum usable power when the HU volume control is turned up to full (or to pre-distortion level as measured with a scope).

NOW you can go and add EQ, or whatever. Remember that IF your HU (or whatever signal source) has high output voltage the input gains on your amplifier maybe set very low. Maybe not even turned up at all! That is a GOOD thing!

REMEMBER that whatever the input gain is set at...we DON'T care! As long as the system goes to full power. And if you can get it to clip on some music (as recordings are all different levels and EQ) then you KNOW you're at Full power. We are GOOD!!

Now lets take a system that has a DSP , and EVERYTHING is active. Tweeters, midbass, subs, etc. Now things get a little more complicated as there is a signal device in the middle of the stream. AGAIN...everything I have taught you stays the same. In this particular system the DSP will be treated like the HU. Al you want as much voltage out of it in the signal path as you can get with the amplifer gains as low as possible. Theortcially anyway.

EXCEPTIONS for setting "Gain" when there is a DSP processor (or Amp/Processor) in the system.

With a DSP in the system there are some things you have to do, BEFORE powering up the amplifier(s)

1. Disconnect the signal from the amplifiers. Physically disconnect the RCA's from the amplfiers. Either at the amplifiers themelves or at the DSP.

2. Preset gains on the amplifers. All HP channels set at 10 O'clock. All LP amplifiers set at 12 O'clock. THESE are just PRESETTING ONLY. You may (or may not) change these later.

3. Go into the software of the DSP and PRESET individual channel Output gains to -6dB and Output MASTER gain to -6dB. This give you 12 dB to "play" with overall when you are doing your final gain settings.

4. Preset Crossovers for all drivers. ESPECIALLY HORN tweeters!!! For example IF you are using "Pro Style" midbass drivers with Horn tweeters the recommended HP crossover is 80-120Hz for the midbass and 6,000-8000Hz for the tweeters HP filter,. At least 12dB per octave slope.

So now the Front and Rear gains and HP filters are set properly. They are at a level where you will have maximum usable power when the HU volume control is turned up to full (or to pre-distortion level as measured with a scope).
NOW you can go and add EQ, or whatever. Remember that IF your HU (or whatever signal source) has high output voltage the input gains on your amplifier maybe set very low. Maybe not even turned up at all! That is a GOOD thing!

REMEMBER that whatever the input gain is set at...we DON'T care! As long as the system goes to full power. And if you can get it to clip on some music (as recordings are all different levels and EQ) then you KNOW you're at Full power. We are GOOD!!
So if you had..say 8 Vac at the beginning (like speaker out of a Harley Radio) But the amplifer can only accept 4 Vac in...then that is BAD...But if you can attenuate the output of the HD radio to 4 Vac out.,..then all is good (DSP or LOC). And the noise floor is lower. BUT remember that the average AC Voltage out from the headunit will be at least 10dB down from the 8 Vac out!

Now lets take a system that has a DSP, and EVERYTHING is active. Tweeters, midbass, subs, etc. Now things get a little more complicated as there is a signal device in the middle of the stream. AGAIN...everything I have taught you stays the same. In this particular system the DSP will be treated like the HU. And you want as much voltage out of it in the signal path as you can get with the amplifer gains as low as possible to get to Full Power. Theoretically anyway.

EXCEPTIONS for setting "Gain" when there is a DSP in the system.

With a DSP in the system there are some things you have to do FIRST, before powering up the amplifier(s)

1. Disconnect the signal from the amplifiers. Physically disconnect the RCA's from the amplfiers. Either at the amplifiers themelves or at the DSP.

2. Preset gains on the amplifers. All HP channels set at 10 O'clock. All LP amplifiers set at 12 O'clock. THESE are just PRESETTING ONLY. You may (or may not) change these later.

3. Go into the software of the DSP and PRESET individual channel Output gains to -6dB and Output MASTER gain to -6dB. This gives you 12 dB to "play" with overall LEVEL when you are doing your final gain settings.

4. Preset Crossovers for all drivers. ESPECIALLY HORN tweeters!!! For example IF you are using "Pro Style" midbass drivers with Horn tweeters the recommended HP crossover is 80-120Hz for the midbass, 6,000-8000Hz for the tweeters HP filter @ 12dB per octave slope.

5. Once those presets are done, SAVE these and “burn” to the DSP . Power the sytem off and on again and DOUBLE check that the settings you did are there and setup inyour DSP device. Otherwise you WILL blow up tweeters!!! Guaranteed!!

NOTE: I would still have the subwoofer off for now and concentrate on just HP front and rear.

6. Once you’ve double /triple checked that your DSP is all “Pre-Set up” - re connect the RCA’s and power up the system (except the sub - for now)

7. Again using dynamic music with the HU volume all the way up (or close) See how gains are? It should be pretty loud already. If it is distorting turn the amplifers gains DOWN. The DSP needs to be the MAIN gain control, EQ, everything!! So it is the last thing to be used. Remember that you still have 12dB oif gain avaliable in the DSP settings. Use it wisely!

8. Adjust all the gains in DSP, up or down. Make sure that levels are good for tweeter versus midbasss. I am NOT going to go into all the setting of the DSP as that is a WHOLE nother discussion about setup. This discussion is how to set gain up.

Next:

9. Turn the system off and reconnect the subwoofer RCA’s.

10. Turn the system on and check subwoofer levels. Use the HU volume control and turn the volume down. This should be done at “normal ” levels. Not super loud as you are trying to integrate the subwoofer INTO the system. At least volume(level) and crossover wise. Since you already preset gains at both the amplifier and the DSP it should be pretty loud already. IF it is too loud, turn the subwoofer amp input gain down.

11. Most people like a little sub-heavy action which is fine if it suits your tastes. With a DSP a lot of this is super easy to do and typically can be done right from your phone (set up anyway) Like our Cicada DSP125.4D amplifier/Processor. Super easy to set up (yes that was an un abashed plug for my product!)

Bingo, you’re about done!

You can if you want, adjust the EQ to your liking. Note that if you boost any frequencies (although most people prefer to ‘cut’), you are pushing the amp a little closer towards clipping. This means, if you now turn the volume up to what was previously the maximum level, the amp may in fact clip because the signal is stronger than before

For this reason, you need to either turn the gains down a little to compensate for this...or never turn the volume up as high as you used when setting the gains.

Finally, realize that some recordings vary in quality. Occasionally you will encounter a recording that is excessively 'high' in level. All that means is that that recording is highly "Compressed" Bear in mind that such recordings will push the amplifier closer towards clipping and you may not be able to utilize the volume control up to full output. For example - Crystal Method recordings are HIGHLY compressed. So are MANY others. BEWARE!!! There is NO standardization for recording engineers, they all have their choices for monitoring speakers, mixing boards, limiters, companders, etc. Basically a "Free For All" in what you get out of every recording and every recording artist.

Importantly, playing test tones (constant frequency), as those used during SPL competitions, makes the RCA preout signal much stronger compared with music. This too will push an amplifier closer towards clipping so you must limit the volume control to below full.
When all the gains and crossovers are set correctly, you will use the stereo knowing that you have all the usable power on tap and can turn it up as loud as it will go with limited risk of damaging your components from excessive power. So enjoy!

Some extra notes:

When tuning a system for sound quality, one of the goals is to get "up-front" bass, (i.e. you want it to sound as if all of the bass is coming from your front speakers, rather than noticing that it is coming from the subwoofer at the rear of the car).

The trick is of course to filter the subwoofer at a low enough frequency, so that your ears cannot tell which direction the sound is coming from and tune the output levels of the system so that the subwoofer blends in well with the speakers covering the midbass in your front stage. This will vary from car to car and system to system (depending on path lengths, subs used, enclosures, etc)

There are two important points to consider:

First, make sure the subwoofer volume is level matched correctly to the midbass and the tweeters. By this, I mean make sure the subwoofer is at a similar volume to your front stage. Otherwise, if the subwoofer overpowers the front stage, the bass will not blend in well and it will not sound that great. On a motorcycle it is SUPER important to add a HP filter to the sub. Bacically a BandPass filter for the sub as letting subs go REALLY low on a bike is NOT a good ide. Unless it is a "Parking Lot Queen". Because as soon as you're moving at 60 MPH or faster (No! Not you guys! Right!) Then bass goes away because of how loud the road AND you bike is. You will try to compensate for that, and crank the sub level up. remember...you only have SO much excursion (XMax) and ONLY so much cone area....it will ONLY play so loud period!! And to"bandpass" you more than likely need a DSP connected to your system. Otherwise pretty tough to do!!

Secondly, it is important to set the high pass (on your front stage) and the low pass (on your subwoofer) filters correctly.

On Motorcycles utilzing CoAx horn drivers or high sensitivity midbass drivers with horns, you'll HAVE TO HP these drivers. Even though everyone says they are "fullrange", yeah...not really.

High sensitivity drivers...high Fs (free air resonance) ...its a law of physics...not a suggestion!!)

The actual crossover points, depends on how low your front stage can play, without distortion.- For example, some speakers, when playing midbass may not play all that low, or they may be limited in linear excursion. So they distort if you try to play them too loud at a low frequency.

(How high the subwoofer can play will technically be a factor too, but there are very few sub-woofers that have such a high inductance that they cannot play to 1000hz).
The installation will also be a variable, particularly the subwoofer enclosure design and location, as well as the installation/location of the front stage drivers, as well as the filters themselves. For example, the alignment (Q) of the filter (if it is a Butterworth or Linkwitz-Riley etc), as well as the slope.

When sound quality is a priority, I would suggest to start tuning the filters at fairly low points (some SQ cars have their subwoofer low passed below 50hz, some at 120 Hz!) and then slowly raising the points, as well as varying how close the high pass (on the front stage) and the low pass (on the subwoofer) filter points get. I personally do not like under or over lapping crossovers.

But…sometimes it helps. The aim is to simply try out the various crossover points and listen to what sounds the best. In the end it doesnt matter what the "machines" say (Oscilloscopes, DVMs. DD1+'s , RTA , etc)

What matters is - HOW DOES IT SOUND? Your EAR is the final ultimate judge of the sound.

Your guide thru this long process - Larry Frederick

Credits :

Our Aussie breathren down under gave this to me over 15 yrs ago. The link does not work anymore. But I want to give credit where credit is due. How audio works has not changed in 30 yrs. It is what it is. Gain is gain. PERIOD!!!

http://www.mobileelectronics.com.au/forums/index.php?showtopic=35875&st=0&p=339173&#entry339173