

DSP Presets and Power Amplifier Voltage Gain

By Marty McCann
Peavey Electronics Corp.
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In order for electronic crossovers, and especially DSP based crossover presets to work properly, all power amplifiers in the system **MUST** have the same amount of fixed gain. Specifically, that is matched voltage gain and **NOT** matched input sensitivities. All Peavey amplifiers have a fixed voltage gain of times Forty (X's 40 or 40X) which is +32 dB of gain on the decibel scale. The voltage gain in some models of CREST power amplifiers are 40X's, while some are 20X's (+26 dB), and some have switchable gain settings that include a common input sensitivity of 0.775 Volts.

The sensitivity of a power amplifier is that specified voltage at the input (with the level control wide open) that will cause the amplifier to reach full rated power. An amplifier that has a rated sensitivity of 1 Volt at 4 Ohms and has a voltage gain of 40X's will then deliver 40 Volts into the 4 Ohm load. $W = V^2 / R$, so $40 \times 40 / 4 = 1600 / 4 = 400$ Watts. On the decibel scale that is equal to a gain of +32 dB ($20 \log 40/1 = 20 \times 1.6 = 32$).

It is also important to understand that when all amplifiers in a model line have a fixed voltage gain, then the rated input sensitivity will be different for each model, according to the maximum power output into a given load. The sensitivity of a power amp will also change depending on the impedance of the load. This is due to the fact that the available output voltage changes to a lower value in Volts when you lower the load impedance. The voltage gain of the amplifier does not change when driving a different impedance load, but the input sensitivity or voltage at the input that causes the amplifier to reach full power, does indeed change. Amplifiers have a lower input sensitivity at lower impedances, simply because the voltage Gain remains the same. This is absolutely important to understand as you must also change or recalibrate such devices as compressors and limiters within the DSP loudspeaker management system.

I will use a Peavey CS-4000 as an example. The CS-4000 is rated at 800 Watts Per Channel at 8 Ohms and 1350 Watts per channel at 4 Ohms. So to find the input sensitivity (again level control wide open), you must use an inversion of Ohms Law to find the voltage that will produce the rated power into the stated impedance load. Ohm's Law says that the power in Watts is equal to the voltage squared divided by the resistance or impedance of the load ($V^2 / R = W$). So the inversion would be the voltage squared is equal to the power in Watts times the load resistance ($V^2 = W \times R$).

So to find the sensitivity of the CS-4000 when it delivers 800 Watt into 8 Ohms; you multiply $800 \times 8 = 6400$. The Square Root (Sq Rt) of 6400 = 80 Volts. Now since this amp has a voltage gain of X's 40 (40x), we divide $80 / 40 = 2$. So the sensitivity into 8 Ohms is 2 Volts.

To find the sensitivity in Volts to produce 1350 Watts into 4 Ohms: $1350 \times 4 = 5400$. Sq Rt of 5400 = 73.485 Volts. $73.485 / 40 = 1.837$ Volts. Now this would often be rounded off to 1.8 Volts, however $1.8 \times 40 = 72$ and $72 \times 72 / 4 = 5184 / 4 = 1296$. So you can see that when using math that involves squaring of numbers, it is best to not round off too soon or too much.

So with the above mathematical foundation you should be able to use the published specifications of any brand of power amplifier to figure out for yourself what the voltage gain might be. I would suggest that each of you urge manufactures to publish the sensitivity into all rated load impedances. Many manufacturers only rate the gain in dB, but most folks that are beginning to get into DSP can not convert dB to the actual voltage gain. Both specifications should be published. Ink is cheap, electrons and bits sent down the Internet pipe, are cheaper yet.

Now for the bad news (for some of you). There are manufacturers that sell power amplifiers with voltage gains that are NOT fixed within a model line, "As they should be" (my quote) in our 21st century where we routinely employ digital signal processors. One way to quickly determine whether the voltage gain is fixed in a given line of models is to examine the specifications. If a model line has say four models with 4 different power levels (example 500W, 760W, 1065W, and 1350W into 4 Ohms); **but**, if all four models have the identical input sensitivity of say 0.775 Volts (or 1.2, or 1.4 Volts), then the gain is NOT fixed within that model line. If the input sensitivity were 0.775 Volts, then in order respectively, the voltage gains for the four amps above would be: times's 57.7, time's 71, time's 84.2, and time's 94.8 respectively. Drive these four amps with a DSP that is expecting a common fixed voltage gain, and you will have severe frequency response problems and possible reliability issues as well.

Two of our biggest competitors of power amplifiers are Crown and QSC. These are both of course very reputable manufacturers, however (I am sorry to report) that many of their products within a given model line do NOT have a FIXED Voltage gain. There are other manufacturers that "resemble this remark" also.

I have seen models with a voltage gain as high as X's 126. $20 \text{ Log } V1/V2 = X \text{ dB}$ difference in gain. So, $126 / 40 = 3.125$; $\text{Log } 3.125 = 0.49485$. $0.49485 \times 20 = 9.897 \text{ dB}$. If you had one of this manufacturers amplifier models that had a X's 126 Voltage gain, instead of a X's 40, your factory preset would be off by +10 dB. On more than one occasion I have talked to customers that had just such an amplifier on the high frequency ribbon drivers in the Versarray VR-112 enclosures.

One customer's faulty linear logic, (which many innocently share) was that he was okay, because he turned down the level control on the front of the amplifier to limit his output power. This makes me want to say a few cuss words. Turning down the level control does NOT limit the amplifiers full output capability (in Watts). It only changes the SENSITIVITY as to what amount of voltage at the input causes the amplifier to reach it full rated output power in Watts. The amplifier now has a voltage gain of times 20 to reach 40 Volts. So if, you have a 400 Watt amplifier that is sensitive to 1 Volt into 4 Ohms, that would be 400 Watts ($40 \times 40 / 4 = 400$). Now, if you turn the input level down to -6 dB, you changed the sensitivity and the voltage gain by -6 dB, you did **NOT** reduce the maximum power output to $\frac{1}{4}$ (-6 dB), as it can still reach full rated power, but it would take twice the voltage at the input to reach the rated maximum power. As it would then be sensitive to 2 Volts at the input to reach 40 Volts at the output, which would now be a times 20 voltage gain.

Now, if you do have one of our digital signal processors for crossover functions and loudspeaker management, then if you must use amplifiers that are NOT fixed in Voltage gain within a model line; LEARN TO DO THE MATH, or buy a Peavey or a CREST power amp.

How do I check my amplifier to determine the Voltage gain?

I would not expect every Saturday night warrior band to have a multimeter. But if you are a regional sound system provider and you do not own or understand the operation of a basic multimeter, then I am sorry my friend, you are simply not yet a Professional. The multimeter is the professional sound mans best friend. Now us “senior citizens” may still refer to them as VOM’s or Volt-Ohm-Meters. They are not very expensive, as the cheapest can be found for under \$20.00 U.S. Yes some are cheap, but better a cheap one than none at all. I would suggest investing in a decent one. I use and recommend the Fluke model 10 multimeter.

Look for models tha thave a true RMS voltage reading function, and are rated for accurate AC voltage measurements out to 20 kHz or beyond. There are also multimeters that have a dB and Relative setting capability that are also very hepful to have. The \$20.00 digital meter may only read AC Volts reliably up to 120 or 400 Hz, and be accurate with only a sine wave input.

Take a signal generator (or CD test set) and set it for a sinewave function at 400 Hz, and set and measure the output to read 1 Volt RMS across pin #'s 2 & 3 of a male XLR cable. Connect this cable to the input of the power amplifier and with the level control wide open and no load on the amplifier, measure the voltage on the outputs. Smaller power amps (below about 200 Watts) may need to use a lower drive level to avoid clipping or distortion. If it reads more than 40 Volts RMS, to match the voltage gain of the amp to X's 40, simply turn the input level control down until you measure 40 Volts for a gain of +32 dB or 40x. Mark this position somehow using masking tape, a Sharpie, or even borrow some of your wife's or girl friends's finger nail polish. (Oh I forgot, in today's world some of you guys can use you own finger nail polish). If you mark the knob, this way if it gets bumpped or changed by a helpful individual who “fixed all the gain settings on the amps”, you can still quickly set it back to where it needs to be. Before firing up the rig, always double-check the gain setting for any power amp you have had to “turn down” this way.

And as a reminder, when it comes to power amplifiers, the mantra is: **Last ON and First OFF.**