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Get the Reference!
3/2005

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The world has many reference points: *Hotter than heck, Colder than a summer day in San Francisco, Faster than a speeding bullet.* Our A/V world has an important reference, too: The correct sound level for a home theater. There is a way to know where to turn the volume dial so you can hear a film the way it was intended by the sound designer and the film director.

Volume control knobs come in many different forms, with level displays that span the gamut. "This one goes to 11!" Remember how sordid that little comment was and how much it stuck? Numbers on a guitar amp knob are usually marked from 1 to 10, with 10 being referenced as the loudest. So repaint the top number 11 and is it louder? Nigel seemed to think so! Those numbers are just a reference, get it?! Some audio gear is also labeled 0 to 10, or 0 to 100, or Min to Max, or $-\infty$ to 0. (But I haven't seen anything from 0 to 11 yet!) When I look at all these combinations, I don't know how loud the middle point of the knob is, how much gain it represents, and more importantly, how close that level is to a soundtrack playing in a cinema. Some A/V controllers and receivers have volume controls marked from $-\infty$ through 0dB up to +12dB. If the product design engineer did the right thing, the gain condition at 0dB will be just right to light up the amplifiers and speakers to produce a predictable sound level. This latest approach gives us the ability to set up a home theater system to match the loudness intent of the film director and to even know how much we are deviating from that intent.

In a cinema, you aren't given a volume control knob with your bag of popcorn, right? The volume level is set up in the projection room by a technician to match the film industry reference levels to which post-production mixing rooms and cinemas are calibrated. (That level happens to be called *Fader Position 7* on the cinema sound processor). The sound you hear is to match the levels heard during creation of the film. There actually is a desired volume for listening to movies. It's the one that was heard during production of the final film soundtrack in the studio. The sound designer, the director, and all the other folks involved in crafting the soundtrack heard it that way.

Realize that the character of sound changes with volume. The perception of bass balance changes, becoming more present as you turn up the level – that’s why audio gear often has a “loudness compensation” function.

Reference level starts back in the studio. Modulation levels on the recording medium, electrical levels in the recording gear (be it analog or digital), amplifier gains, and speaker levels are all carefully adjusted to ultimately get to a sound level of 85dB SPL at the mixing position when the meters on the recording console register 0 VU.

Why call this level 0 VU? Zero may sound like there’s no sound at all. Why not 100% with 1% being very quiet and 120% being really loud? In the world of audio, many things are measured in dB, which is a calculation of difference from some reference. The term dB is short for decibel, in homage to Alexander Graham Bell. The decibel is a ratio comparison between any two numbers as expressed by the equation:

$$\text{dB difference} = 20 \log (a/b)$$

Don’t worry; you don’t need to whip out the scientific calculator. Just know that, as opposed to a pound, a meter, or a furlong, a dB is a relative number. Sometimes, decibels may seem to be used to express an absolute value, such as sound levels that are expressed in dB. However, if you dig a bit, you will find the reference to which these sound levels are compared. In acoustics, the reference sound level is 20 micropascals of pressure, which represents the smallest amount of sound a human ear can detect. In the dB world, this level of pressure is called 0dB SPL. So, a sound of 85dB SPL just means that the air pressure generated by the speaker is 85dB higher than 20 micropascals. In professional audio, levels are often measured in dBm. Now, there’s another interesting story: 0dBm is the voltage that would yield 1 mW of power across a 600 ohm resistor. That happens to be 775 mV. Why this odd number and not simply a reference to 1 volt? It’s from the early days when all the engineering and gear was borrowed from the telephony business where loads are 600 ohms and power is precious. The pro audio business adopted that measurement method and still runs with it. (Most recently, the 600 ohm impedance has been dropped and the scale changed to dBu. It is still referenced to 775 mV.) Once in a while you will see a dBV expression, which is more simply referenced to that 1 V value.

In a home theater system with a referenced volume control, the number on the dial is the dB difference between what you *are* hearing and what you *should be* hearing. Zero dB (0dB) means that you are 0 paces away from perfection. Minus 11dB (-11dB) means that you are 11 steps down from “just right.” The sound is too quiet, and the overall balance won’t match the intent of the director. The bass levels will be too low. Dialog may be inarticulate. Impact may be altogether gone.

Once properly calibrated, a reference home theater with volume at 0dB is the exact sound level that the filmmaker heard when the soundtrack was going through its paces. The cool thing is that if you walk up to this reference home theater, you will know right away how loud it will be when the volume display indicates -4dB, +6dB (hold your ears!), -30dB, or any other value.

So how does all of this apply in everyday use? Calibrated reference levels are the one place you can get predictability. If you set up a system according to film industry standards using an A/V controller with a referenced volume control, then you know that when you drop in a DVD of *Spinal Tap* it will play at the same level as the ten other movies you watched this week. You may think the resulting level is too loud at times, since films are mixed pretty hot these days. You can turn it down a predictable amount, like 3 or 6dB, and again you will know what to expect. Pretty nice! Now let's see if someone will come up with a way to predict, within one dBt (a measure of time I just invented), how long it takes to calibrate a home theater system!

This article is based on a column published by A. Grimani in Residential Systems magazine March 2005.