The Amplifier Guru speaks: Bob Cordell

Amplifier Questions

In layman's terms, what exactly did your research show back in the 1970's?
I did a great deal of work studying power amplifier distortion mechanisms and types of amplifier distortion measurement. Transient Intermodulation Distortion Distortion (TIM) was a cleverly-devised and over-used buzz word for high frequency distortion created by amplifiers with inadequate slew rate. Its inventor incorrectly interpreted his math equations and wrote several papers asserting that TIM was caused by the use of large amounts of negative feedback. So emerged the myth that low-feedback/no-feedback amplifiers are superior. Not so, but it lives on to this day. Even a special TIM distortion test was developed, but it turns out that 20 kHz THD and TIM are highly correlated. Any amplifier that has low 20 KHz full-power THD (say, less than 0.02%) has essentially no TIM, whether it uses negative feedback or not. Unfortunately, lots of other mechanisms can result in high THD-20, such as output stage switching distortion.

Without giving the standard weakest link answer, how important is the amp as a component?
It is very important, but not nearly as much so as the loudspeaker. The job of the amplifier is very simple. It must multiply the incoming signal voltage by a factor of about 20, and deliver a perfect replica of the signal to the speaker, independent of the impedance that the speaker presents to it. It is not the job of the amplifier to modify or "improve" the sound in any way. The name of the game is accuracy in combination with adequate power and absence of misbehavior.

How important is the power supply in power amps?
The function of the power supply is to convert the incoming a.c. line into the necessary d.c. voltages for the amplifier. It is especially important that adequate short-term current reserves be available for when musical peaks demand that large currents be delivered to the loudspeaker. Most power amplifier power supplies are unregulated, so their voltage will fluctuate by some amount in accordance with the current demands of the output stage. Their outputs will also contain some a.c. "ripple" as a result of the rectification process. It is the job of the large filter capacitors to minimize this ripple and provide good short-term high-current capability. The larger the caps, the better. Well-designed power amplifiers are fairly immune to ripple on the power supply and voltage fluctuations, with the exception that these imperfections come directly into play when the amplifier clips, since the power supply rail voltage sets the maximum achievable output before clipping. Power supplies with higher ripple will tend to sound worse when they clip, since the instantaneous clipping power will tend to be modulated by the 120 Hz ripple on the power supply. Power supplies with larger power transformers and larger amounts of filter capacitance will help an amplifier sound better. Put simply, the power supply is important to the extent that it is under-sized.

If capacitors act as a power supply reservoir for an amp, will power cords, receptacles, dedicated lines, or power conditioners really do anything since they are before the caps Is there science behind this?
The amplifier power supply draws almost all of its current from the a.c. line only during the short time interval at the top and bottom of the sine wave when the rectifiers are conducting. This time interval may only be 10 percent of the total cycle. An amplifier drawing an average of 200 Watts from the 120V line, or about 1.7 amps average, will actually be pulling that current in 0.8 ms bursts on the order of 11.8 amps twice each cycle. This means we'd like to keep the TOTAL a.c. line resistance low, not just that of the six-foot power cord. It is not unusual in a house with 14 AWG Romex to see an a.c. line impedance of as much as an Ohm at the outlet. Try it yourself and plug a 1200 Watt hair dryer into your outlet and measure how much the line voltage drops under this "10-Amp" load. Thus, when your amp demands a burst of 12 Amps from a nominal 120V line with an impedance of one Ohm, you'll lose about 12 volts at the peak, or about 10% of your supply voltage. Since power goes as the square of voltage, the peak output power capability of your amp will drop 20% as compared to a perfect 120V line voltage source. This sounds bad, but the simplest cure is to

use a slightly larger power amplifier in the first place. Better house wiring, and maybe a dedicated 10 AWG line to a 20-Amp breaker will help a lot (much more than a $100 6-ft beefy boutique power cord). If the power supply is well-designed, fancy power cords, outlets and power conditioners shouldn't matter much. Spend $2.50 on the Home Depot outlet rather than 49 cents, just so it is well-built and provides a good, reliable connection. Getting rid of hash, RF noise and transients on power lines is the job of a power conditioner, not an expensive power cord. Spend $50 on a good power strip with an EMI filter to protect your equipment, and you'll have most of the benefit you need. It is ironic that fancy stuff like this is associated with high-end audio gear, when it can be argued that the cheaply designed, mass-marketed stuff should need it the most. There appears only to be pseudo-science behind power cord marketing. The argument for boutique power cords is far weaker than the argument for boutique speaker cables, and even the latter is on thin ice at times.

Is this true of power supplies for all components?
So are power supply upgrades worth it on any device? To the extent that the power supply in the original unit is not well-designed, power supply upgrades are worth it. For example, the power supplies in pre-amps and CD players want to be regulated well and with low noise. Of course, if you are paying $500 or more for a preamp, it should darn well already have an excellent power supply. Current demands in this kind of gear are very low, and it is not expensive to build a very good power supply into the unit. Power supply upgrades are most likely to make a difference in inexpensive mass-market components where every penny was pinched (or in high-end gear where the designer didn't know much about power supplies).

Someone recently said that if not driven to clip, all SS sound the same. Do all SS amps sound the same?
No, because they all misbehave differently. However, well-designed SS amps operating well below clipping, that are not misbehaving, and which have high damping factor across the band, will tend to sound the same. Note that some very expensive SS amps do not meet the criteria of this caveat - sometimes as a result of misguided design decisions intended to "improve" the sound. A very expensive no-feedback SS amp may sound different because it has a low damping factor, which in turn will cause coloration when the varying impedance of a loudspeaker is being driven. Some people might mistake this coloration for "better", but is merely a departure from accuracy. Different SS amplifiers will often sound different if they are driven into clipping (which happens more often than some realize). Some amplifiers clip more gracefully than others. The same thing applies to amplifiers that include protection circuits. Some amplifiers in the 70's had protection circuits that could manufacture a violent spike when they engaged. Urban legend has it that they were sometimes called "tweeter-eaters". Finally, some (often high-end) amplifiers are designed with inadequate stability margin when driving capacitive loads, like some boutique speaker cables. Stability may have been sacrificed in a misguided attempt to make them somehow more transparent to high frequencies, for example. These will certainly sound different if they occasionally burst into oscillation.

Flipping the coin over, what does make an amp sound great?
Absence of any kind of misbehavior and graceful clipping, lots of power, high current capability, graceful or no protection circuits, absence of coloration (flat frequency response when driving actual speaker loads), and stability under capacitive loads. Added features making for good sound include good power supply reserve, good power supply line layout and very stable feedback. All of this is achievable with good solid engineering design, with attention to detail, but without resort to black magic. Some of it costs money, like a good power supply and large heat sinks that allow transistors to be well-biased and still run reasonably cool. More output transistors in the output stage costs more, but reduces the need for intrusive protection circuits. I strongly prefer MOSFET output stages to bipolars, and their cost premium is continuing to come down. Unfortunately, some designers are afraid of them and some other designers don't know how to make the best use of them. Many MOSFET amplifier designs like to run hotter than bipolars, and that drives up the cost of the heatsink.

Do preamps affect the sound more than power amps?
Only if they are really bad, or, perhaps deliberately, incorporate circuitry and technology that will color the sound. Use of pots that track really well is important to balance and imaging. Preamps that incorporate digital signal processing are a possible exception if their A/D and D/A circuits are not of very high quality. Preamps that use poor-quality voltage-controlled gain circuits in place of high-quality potentiometers might also introduce some degradation as well. Good quality pots are a must for a good preamp.

Is the op-amp mania in audio circles valid?
No. Op amps got a bad reputation in the Seventies, when cheap general-purpose op amps were used in audio electronics. Op amps have come a long way. Quality, audio-grade op amps, costing between 2 and 5 dollars (sometimes even less) are superb, and usually much better than anyone could do with a discrete design. Of course, there are likely some misguided or inexperienced designers out there who may improperly apply an op amp.

Looking at basic amplifier spec sheets, what should we really look for?
Spec sheets in many ways are nearly worthless. If someone specifies according to the FTC standard a THD at full power out to 20 kHz of less than 0.02%, the amp is more likely to be good sounding, but this is not fully necessary or even sufficient. Depending on the nature of the distortion and misbehavior, an amplifier with 0.1% THD can sound great, and an amp with 0.02% might sound awful when it clips. I'm not saying to throw out the spec sheets, but they just don't usually tell the whole story. Forget about spec sheets for boutique amps.

Without getting into how power is measured, how much power do we really need?
Much more than we think. Ideally, if you are really serious about high-end audio, your amplifier should never, ever clip. In reality, amps clip more often than we think, especially on well-recorded music that has high dynamic range, and especially when driving speakers with efficiencies in the low to mid 80's. My 250 WPC amplifier will occasionally wink at me with its clip LEDs (every amp should have them!) when driving my Morel M3 speakers with well-recorded music at levels that are realistic but certainly not painful. Remember, the peak-to-average power ratio (crest factor) of well-recorded music is quite high. The average level is what drives us out of the room, while it is the peak level that impresses us with effortless dynamics. If a 100 Watt amplifier is adequate for a speaker with 91 dB sensitivity, you need a 400 watt amplifier for a speaker with only 85 dB sensitivity. Put together inefficient small-diameter woofers with adequate baffle step compensation and you have a recipe for a speaker with small net efficiency, often less than 85 dB.

What is the future of amps?
High-end audio will forever embrace "big-iron" power amplifiers. However, on the average there will be migration toward more use of IC power amps, like the LM3886, and the use of Class-D amplifiers. However, it seems unlikely that one will ever make a Class-D amplifier that can sonically outperform the best-designed Class A-B amps. The newer, less expensive and more compact amplifier technologies may also help foster the migration of the power amplifiers into the cabinets of active loudspeakers.

So which is it, tubes or SS?
If you like uncolored sound, go solid state. If you like the coloration that tubes add to the sound, then go with tubes, recognizing that the coloration will often be a strong function of what speakers are used. Tubes clip more gracefully than most solid state amps, but again, if you are serious about high-end audio, your amp should never ever be clipping, whether it is tube or solid state. Because tube amplifiers tend to be capable of less power, they will be clipping more often into a given loudspeaker.