AN IMPROVED POWER AMPLIFIER DESIGN

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THE GOAL

In a perfect world, a perfect power amplifier would increase the input signal voltage to suitable levels for driving loudspeakers. It would also have infinite amounts of output current available as needed by the speaker. This implies zero ohm source impedance, otherwise known as infinite damping factor. And all this would be done with no distortion.

THE CHALLENGE

In our real world of electronics, we are able to design an amplifier that outputs enough voltage and current for virtually any loudspeaker, and come very close to a zero ohm source impedance. However, the goal of achieving low distortion has been compromised by the transistors themselves.

When the silicon dies are fabricated, the process results in a good transistor. However it also has a capacitance in the die which is impossible to remove. This "parasitic" capacitance takes time to charge and discharge as the voltage changes thus slowing response. It must be carefully dealt with in the amplifier's design.

A typical design including Boulder's, has a group of transistors providing positive current on the positive voltage swing of the signal. Another group of transistors provides negative current on the negative swing. The difficulty arises when the output voltage swings through the zero point, as the positive group is turning off and the negative group is turning on. That is when the delay caused by these parasitic capacitances causes "crossover" distortions to happen adding grit to the sound. It is thus necessary to provide additional current to charge and discharge the capacitances in order to maintain adequate transition speed and give low distortion, especially at the highest frequencies.

TRADITIONAL SOLUTIONS AND THEIR PROBLEMS

The most widely used solution increases idle current in the transistors which is then available on demand for the task of charging and discharging the capacitances. This extra current is known as bias. For audio amplifiers it generally falls into two categories, known as A bias and AB bias. Of the two choices, the A bias scheme works better because by design the output transistors always have more current flowing through them than is needed to drive the loudspeakers. This is also more than enough to drive the parasitic die capacitances. The downside to this is that the amplifier always runs hot and the mains current consumption is always high—basically it becomes a room heater.

Boulder 2000 and 3000 Power Amplifiers use a special version known as "sliding A bias" which senses high signal levels and raises the idle bias accordingly. Over 25 years, this has proven to be a very good solution giving performance which wins the listening tests—without being a constant room heater.

For those that prefer not to sweat while listening, the AB bias version is a modification which is only true A bias when the output is at low levels. When higher voltage is needed, the design changes into B bias because it completely turns off the opposite polarity group of transistors. While this design reduces the heat and power dissipated, the point of transition is nebulous, and can only be approximated for an "average" loudspeaker. In practice it can be made to work very well and is used in Boulder 861 Stereo Power Amplifier and 866 Integrated.

For all series of Boulder Amplifiers, we use as low a gain as possible in the output stage which greatly increases correction for distortions, further optimizing the sound quality of each of these bias schemes.

NEW IDEA FROM BOULDER

Boulder decided it was now time to take a fresh look at power amplifier output stages and the parasitic capacitance problem. Boulder's new "Smart Current" output stage is the result of a year's effort studying and coordinating all of these design requirements. Here is the story of our new development.

Various factors were taken into consideration. Naturally the Safe Operating Area (SOA) of the power transistors was primary. Thermal issues including the temperature of the transistors and heatsinks were studied, as well as fail-safe temperature limiting circuitry. Every brand of electronics is subject to reliability issues if allowed to run hot—heat is electronic's natural enemy. In particular heat can shorten the life of electrolytic capacitors. Therefore Boulder has always used the higher temperature rated capacitors. Various microcircuit and resistor parts are analyzed for their SOA as well. Through these studies and design practices, Boulder has reduced the failure rate to very near zero.

Historically, a designer has had to choose which class, typically A or AB to use in the amplifier design. Boulder's desire for this new approach was to eliminate class distinction. This advanced thinking would create a fully automatic approach for the output stage design.

Another design goal was to have a very robust circuit with no part tweaking or trimming potentiometers used. This enables smoother factory production with less opportunity for human error and easier field repair. Throughout Boulder's history, we have used an in-house designed component test fixture and software for creating super-precision matched resistor sets. These are primarily for repeatable gain calibration and common mode signal rejection. This proprietary testing technique would now be employed in a new output stage design.

Keeping all of these design factors in mind, the key concern remains how to prevent both groups of transistors from being off at the same time. More to the point, how to make certain the opposing transistor group starts to turn on well before the transistor group delivering current turns off. And the new approach would have to work at all audio frequencies. This design technique would continuously adjust the current margin, which is always needed to be present.

Boulder's Smart Current output stage continuously monitors the current drawn by the speaker and self-adjusts as needed. Regardless of the audio frequency or level, this

Smart Current approach eliminates the damaging effects of parasitic capacitance. The occurrence of crossover distortion is so reduced to near zero as to be totally inaudible.

The sophistication of this Smart Current output stage is beyond anything previously done by Boulder or any other manufacturer. It gets us closer to the goal of a perfect power amplifier than ever before.

The 1151 Mono, 1162 and 1163 Stereo Power Amplifiers use this new design. Also it is used in the recently introduced 851 Mono Power Amplifiers. In listening tests, everyone has agreed that the clarity of the sound is significantly improved. We invite you to do your own comparisons.

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