Letter to the editor

Marcel van de Gevel writes:

Dear editor,

It was very nice to see Mr. Joffe's article about class-AB bias loops in Linear Audio volume 6. I hope his article will help to increase the popularity of this elegant technique. Ever since I first heard about class-AB bias loops (around 1994, although Frans Tol and Johan Huijsing used them in op-amps as early as 1976), I've been wondering why they are used so little in (almost) discrete audio power amplifiers. They provide an elegant solution to several problems. First and foremost, they keep the quiescent current from varying all over the place due to output transistor temperature variations due to the dynamics of the music, thereby ensuring that the crossover distortion on real music will be no worse than on the steady sine waves normally used for distortion tests. With a proper choice of the non-linear function they can also keep the output devices from switching off, as Mr. Joffe shows in his Figure 5. On top of that, they give the designer more freedom in choosing an output stage topology. With more conventional methods you are more or less forced to use some sort of complementary or quasi-complementary voltage follower as the output stage to get class-AB behaviour.

There are a couple of things that I have additional questions about, though. When I built my own exp(-R*I1)+exp(-R*I2)-rule class AB amplifier in the mid-1990's, I tried to ensure that the class-AB control loop was fast compared to the normal signal feedback loop and tried to avoid any form of lag compensation in the class-AB loop. The idea behind this was that the class-AB loop should be fast enough to determine how the current is distributed between the output devices, even on the fastest signals the amplifier can handle. Mr. Joffe seems to have a different opinion judging by the use of an integrator in his Figure 8. My question is, how does such a loop behave for large high-frequency signals? Do you get a smooth transition with increasing frequency from the exp(-R*I1)+exp(-R*I2)-rule to a product rule enforced by the output transistors Q24 and Q25 in figure 9? What happens to the quiescent current and to the minimum currents?

The second issue is the use of current mirrors without emitter degeneration resistors. These have two disadvantages and two advantages compared to current mirrors with emitter degeneration: they are quite noisy and sensitive to transistor mismatch, but they have better high-frequency behaviour than the version with emitter resistors (the right-half-plane zero lies much further away) and they suffer less from polarity inversion issues when the mirror output transistor saturates. Mr. Joffe counts on 10 mV mismatch between his transistors, which is already a good figure for discrete devices, but would still produce an error of +47 % or -32 % in a non-degenerated current mirror. Can the circuit actually handle this or should one match the devices by hand to some tougher matching spec? I know from experience that it is usually not too difficult to find discrete transistors that match within a millivolt or two when they are from the same manufacturer and same batch. 2 mV translates to +8 % or -7.4 % in a non-degenerated mirror.

Marcel van de Gevel
Haarlem, The Netherlands

Daniel Joffe replies:

I thank Mr. van de Gevel for his kind remarks about my article. I would especially like to thank him for his thoughtful comments and suggestions.

I agree with his assertion that the current mirror matching would benefit by adding some matched degeneration resistors. I had considered including them, but left them out of the design to save a bit of space and time on the circuit board layout. My decision was made under a tight deadline owing to my underestimating how long certain things would take to accomplish. My feeling probably mirrors Mr. van de Gevel's, that the enhanced matching would be beneficial, but I haven't yet had time to simulate or calculate the degree of the improvement.

As to the integrator-based compensation, I too would have liked the bias control loop to be even faster. Still, the integrator provided quick enough control as well as a robust and simple answer to the compensation question. If the quiescent current compensation loop were faster, I might not have included the controlled clipping circuits. But then again, they give such nice waveforms in response to overdrive that I would probably include them even if a wider bandwidth compensation method were possible.

I hope to have time soon to investigate these questions in greater depth.