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Face-to-Face

Amplification: Is Class D Better Than Class B?

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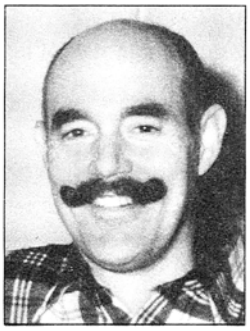
Johnson



Killion

Johnson: I'll tell you how bad it is! Every time I turn around I hear someone saying something silly about the class D amplifier. I don't know whether I am encountering naïveté or dishonesty, but it seems ubiquitous.

I don't mean to disparage the class D amplifier. I think it is a fine idea—and well carried out. But sometimes the copy makes it sound like it is a breakthrough of acoustical significance. Nonsense!

When compared to conventional class A amplifiers, class D shines, of course. It is not practical to bias class A amplifiers with enough current to provide sufficient headroom in most cases. But I think Knowles' claim that people prefer class D over push-pull amplifiers is simply naïve science. The advantage of class D over push-pull amplifiers is a savings in current. But push-pull amplifiers can be quite low-current devices. Both amplifiers deliver high currents only when the signal demands it. Both are eminently practical for high-fidelity or high headroom applications.

Knowles claims that people preferred class D over push-pull in listening tests. They do not say what the characteristics of the test amplifiers were. Did they have identical gains, frequency responses, saturation levels, and peak frequencies? If not, the test cannot be considered a test between two classes of amplifiers because the results will be dominated by other variables.

Perhaps, because the class D amplifier is immutable, many are of the opinion that output-stage amplifiers are all fixed gain blocks. In Ultima push-pull amplifiers, however, the output stage can be set for more or less overall gain than the class D amplifiers. It can be set for higher or lower saturation levels and more or less gain in the high and low frequencies. The peak can be shifted down. And the amount of current expended in saturation can be programmed. It can be set to match very closely the response of all of the class D amplifiers I have seen. When that is done, I find that the two amplifiers are virtually indistinguishable. When that is not done, I don't believe any comparison can be considered a comparison of class D versus push-pull. That would be like obtaining a random aid from company A and a random aid from company B and setting up a test to see if people preferred company A or company B. In that case, the losing company would no doubt quickly point out the test was flawed. In this case, the manufacturers of push-pull amplifiers have not responded for so long that there seems to be some misinformation afoot.

Killion: Much of what Bill is trying to say is, I believe, summarized in Figure 1: Class B amplifiers are almost as good as Class D amplifiers. Good Class A amplifiers eat batteries as if there were no tomorrow, on the other hand, so no one designs good Class A hearing aid amplifiers. Good Class B and Class D amplifiers permit 2–4 weeks of battery life in hearing aid applications. Class D amplifiers are more efficient than Class B amplifiers of equally competent design, but

Editor's Note: Knowles Electronic, Inc. was asked if they would like to respond to Mr. Johnson's comments. They initially indicated an interest but in a later letter stated, "While in our initial reading of Mr. Johnson's proposal, we did express some interest, we now feel that we must respectfully decline."

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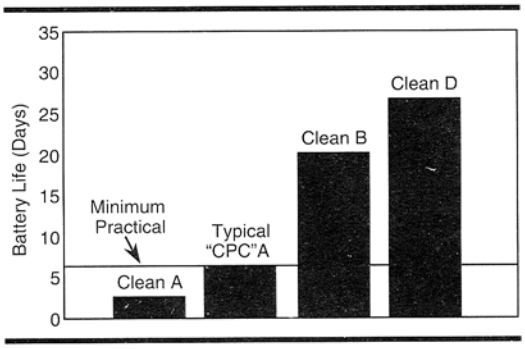
FIGURE 1. Battery life vs. circuit type.



only 30–40% more. In hearing aid practice, this might amount to the difference between 2–3 weeks and 4 weeks of battery life. Either provides a dramatic improvement over the 1-week battery life of a starved Class A design (defined below), or the 1–2 *days* battery life of a good Class A design.

The thing that distinguishes well-designed push-pull amplifiers in listening tests is not whether they are Class A, B, or D. All other things being equal, competently designed amplifiers of any class cannot be distinguished from one another on the basis of even the most careful listening tests. In the lunatic-fringe high-fidelity world, $10,000 Class A vacuum-tube amplifiers are still available, even though they provide no audible benefit in fidelity over $300 all-transistor Class B designs.

The thing that distinguishes amplifier classes is their battery drain. This is of relatively little concern for high-fidelity amplifiers that take their power from a wall socket, but it has precluded high-quality Class A amplifiers in hearing aids. To emphasize the point: I myself used class A amplifiers in the experimental high-fidelity hearing aids constructed for my PhD research. In listening tests, those hearing aids were rated comparable to monitor speaker systems used in recording studios. The problem was that they required 5 mA of drain; they would eat up a 10-A battery in *less* than a day! As Harry Teder bemoaned picturesquely some years ago (before Class D receivers were readily available): "All my problems can be traced to the fact that I had to power the hearing aid from an aspirin tablet instead of Hoover Dam!"

As a practical result, Class A amplifiers designed for hearing aids have been intentionally starved for current, which means they don't have the strength to produce a decent undistorted output, especially at high frequencies. This has earned them several titles. The most accurate is probably "starved Class A." The one I like best is Ruth Bentler's "Crummy Peak Clipping" Class A, where the "CPC Class A" label comes from in Figure 1. (Before the perceptive reader leaps for the typewriter to point out that *all* amplifiers must clip the peaks soon or later, let us agree that what is at issue here is the particularly ungraceful way in which starved Class A amplifiers approach their limits.)

At the time the first Class D receivers were introduced, the readily available Class B amplifiers required a pair of large capacitors to operate properly; capacitors that were almost as large as a small hearing aid receiver. This meant that their theoretical advantage was of no practical consequence for the in-the-canal hearing aids, or even for the smaller ITE hearing aids.

TABLE 1. Johnson's comparison of the Knowles class D to the Ultima push-pull output stage.

Knowles Class D Output	Ultima Push-Pull Output
Lowest current	Low current
No crossover distortion	Negligible crossover distortion
Smallest (output stage in receiver)	Small (on chip with preamplifier)
Several power levels available	Widest selection of power levels and MPO adjustable with a trimmer
Peak can be mechanically damped	Peak can be electrically damped and shifted down in frequency
Gain fixed	Gain can be set from 0 to 40 dB
Frequency response fixed	Both high and low frequency response can be adjusted
Saturation current high	Saturation current adjustable
Can cause heterodyning problems	No clock to complicate matters
Power versions can become unstable with small batteries	Some versions have circuitry to prevent this malfunction
Adds several dollars to the cost	Is virtually free (on the same silicon with the preamplifier)

Bill Johnson claims to have designed Class B amplifiers that do not require large capacitors, have very low distortion, and have very low idling current. I'm inclined to believe him: Bill is an excellent IC designer and a good jazz piano player.

With regard to the Knowles claim that "Class D sounds better than Class B in listening tests," I have not seen the exact literature in question, but would agree with Bill that any such statement would need severe qualification. On the other hand, having worked at Knowles for some 21 years, and having a firsthand chance to see the care with which any such experimental comparisons were normally undertaken, I suspect that the Knowles experiment itself was designed to be as fair as possible to the components available at the time. An equally careful experiment using Bill's amplifiers might well produce a different result. To the extent that Bill's claims are correct, I would expect no one could hear any difference.

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