Self On Audio

The Collected Audio Design Articles of Douglas Self
Third Edition

Review by Mike Rivers

Douglas Self has been designing audio products for over 40 years, constantly on a quest for the lowest noise and distortion at a sensible cost. Some of his creative designs grew out of many years studying, identifying, isolating and measuring a dozen different sources of distortion in both small signal and power amplifiers. For many years, he generously maintained a web site full of technical papers on ways to improve the performance of audio hardware. Along the way, many of his articles describing his analysis, testing methods, discoveries, and original designs, were published, primarily in the British magazine Wireless World (now Electronics World). Self is himself a Brit, so a bit of his native British terminology creeps into his writings. Over the past several years, he's curated his writings and published them through a series of books: Audio Power Amplifier Design, Small Signal Audio Design, The Design of Active Crossovers, and the subject of this review, (and now in its third edition) Self on Audio.

Many of Self's designs were originally published as do-it-yourself projects for the high end audiophile, which explains why the book's chapters on preamps are about phono preamps rather than mic preamps. However, pro audio is definitely in his background. He was chief design engineer at Soundcraft Electronics during the period where Soundcraft's traditional "heavy iron" mixing consoles evolved to bring the "British sound" to the smaller studios emerging in the 1990s.

I heard Self speak at an Audio Engineering Society convention a few years back as a participant in a panel as part of the convention's Product Design track. During the panel session, he described some cost effective tricks he employs for improving the performance of audio equipment. One example, which appears in a few articles in this book, is the lowering noise and distortion through the use of multiple inexpensive op amp ICs in parallel rather than higher cost low noise parts. He's quite a fan of the 5532 dual op amp, which appears in a number of designs including a fully engineered very low distortion power amplifier with its output stage comprised nothing more than 5532s – 32 of them!

I caught up with Doug after the AES panel session and asked about the cross-coupled ground-compensated output stage in my Soundcraft 600 console. He allowed as how it was a good idea at the time, but that today there are better ways of accomplishing the same goal.

Now that I've introduced you to the author, since this is a book review, I should tell you something about the book. It's a collection of 45 articles, divided about equally between preamplifiers (small signal devices) and power amplifiers (large

signal devices). There are two things that raise the book above a mere compilation of previous publications.

First is an extensive preface to each article in which the author provides some background on why the article was written, what the design goals are, how he went about meeting them, what worked, and what didn't. This background material is important in understanding his design process, and that's what he really wants to convey, as opposed to simply providing a guide to duplicating his engineering efforts. There are section-by-section tours through block diagrams supported by discussions of the tradeoffs leading to the final selection of components.

Second is that the thoroughness of the design process comes through loud and clear. Over the course of a series of articles, he identifies and characterizes twelve specific sources of distortion in power amplifiers, shows how these can be isolated and individually measured, and explains how and why different sources of distortion are interrelated; that changing a component or circuit to eliminate one problem source might create a new problem that needs to be solved.

Here are just a couple of examples of his studies to show you how he thinks about design:

In the preface to a 1976 preamp design article, he mentions the use of small value non-electrolytic (film) coupling capacitors rather than the electrolytic capacitors that are so common in today's designs. His choice in 1976 was influenced by the lack of high quality and long-life electrolytic capacitors at a decent price. He writes that today, since we have better quality components, he wouldn't have to make that compromise. He found that by using a capacitor that was of substantially greater capacitance than that necessary to achieve the required low frequency response, non-linearity introduced by the capacitor be reduced significantly. In a solid state amplifier, there's usually only a small voltage across a coupling capacitor, which suggests that a high value electrolytic coupling capacitor with a low voltage rating could replace a more expensive and physically larger film capacitor without compromising performance.

In the pro audio world, the term "Class A" is usually only in the marketing description of a mic preamp. The class of an amplifier doesn't refer to quality, but rather, in what region of the input-versus-output characteristic curve an amplifying device is operating. An amplifier biased for Class A operation is a good design for low distortion, but it's very inefficient, and therefore is usually reserved for small-signal applications where there's little power involved. Class AB and Class B designs are more commonly used in power amplifiers due to their higher efficiency.

One of the bugaboos of a Class B amplifier is crossover distortion, a little glitch at the point in a cycle at the "zero crossing" where the signal waveform switches

from positive to negative. With a Class B amplifier, the positive and negative portions of the waveform are amplified by two separate devices (or circuits), with a change-of-command at the waveform zero crossing; one half of the Class B amplifier quits and the other half takes over. It's tricky to get the bias correct and stabilized so the distortion in the waveform at the crossover point is minimized. In one article, Self proposes a new amplifier class that he calls Class XD (Crossover Displacement), where the crossover between output devices doesn't occur at the waveform zero crossing. This allows the amplifier to operate in Class A at low signal levels and Class B when higher power is required. This design has been adopted in a few commercial products, though XD hasn't yet been accepted as a new class name.

Two articles and their prefaces offer an excellent tutorial on balanced and unbalanced connections. The author works through six different output and three different input configurations (giving 18 possible ways they can be interconnected), showing how each one works, and the best and worst ways of interconnecting them. The goal of a balanced connection is to maximize common mode rejection, and here he explains that an active input circuit that has unequal static impedances between each of the two signal input leads and ground can still provide excellent common mode rejection because, in operation, feedback from the output to the input of an op amp can effectively change the dynamic impedance that a balanced source sees. My only quibble with terminology in this book is with this section. I come from the Bill Whitlock (from Jensen Transformers) school of balanced connections. In Whitlock's terminology, only outputs are balanced. Inputs aren't balanced, they're differential. This makes good sense to me, though Self refers to balanced inputs as well as outputs – as do most manuals, marketing materials, and popular magazine articles.

Self On Audio covers an amazing amount of territory considering that its scope is limited to solid state amplifiers. You won't read the book start to finish in one sitting. In fact I haven't yet read every chapter thoroughly and I've had it on the coffee table for a few months now. It's not a hard read like some technical reference books, perhaps because it's not really intended to be a reference or tutorial, but rather a series of examples of how circuits are designed. The readability of the diagrams and clarity of illustrations is a credit to the author and publisher.

Bear in mind that you won't learn about tube equipment from this book. There's nothing "phat" here – Self's goal is to design amplifiers to be as accurate as possible, with the same sound coming out as going in, only louder. The articles tend be pretty detailed technically and assume that the reader has a knowledge of basic electronics. This is somewhat cushioned by the prefaces which, if they don't tell you what you don't know, at least hint at what you need to know in order to follow the diagrams, graphs, and tables within the articles. It's massive. The 526 page paperback edition that I have weighs in at a bit over 2 pounds. It's not cheap, around $75 in print, a little less as an e-book and a lot more as a

hardback. If you're interested in analog audio design, however, you'll find a lot here. It's organized so that you can read just about any article on its own and learn plenty. It'll keep you busy for a long time.

While the title is Self on Audio, Self on Self would also be an appropriate title. He's not afraid to criticize some of his own work, and lets you know what prompted a lot of the projects that he's undertaken.

Many of the articles were written in a manner that would make for good projects for the experienced builder. At the time of initial publication, there were a couple of companies that offered circuit boards and parts kits to support home construction of many of the projects. While the original parts suppliers have faded into the sunset, The Signal Transfer Company in the UK currently offers kits for a few of the articles in this book, and it appears that they'll ship to the US for actual shipping cost. The Signal Transfer kits include detailed instructions and, for some, a pre-punched and stenciled chassis with matching knobs and switches.

I'd recommend this book to anyone who is serious about learning about audio design and perhaps wants to dabble in some building. It's not, however, for those interested in weekend audio projects, nor is it a tutorial on fundamentals of electronics.

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