

LOW-DISTORTION, LOW-FEEDBACK POWER AMPLIFIERS

BY R.N. MARSH

THE COMPLEMENTARY-DIFFERENTIAL input with complementary push-pull drive and output has been with us for more than a decade. Most of these designs have depended on large amounts of negative feedback to reduce static distortion, but in 1976, W. Marshall Leach published a low-negative-feedback design of this popular topology (*Audio*, February 1976). Since then, home constructors and commercial manufacturers have designed and built many variations of this circuit.

Manufacturers and designers still face one dilemma, however. Low-feedback designs generally have higher levels of total harmonic distortion (THD) than high-feedback units. This problem offsets the advantages (such as wide open-loop bandwidth and a flatter open-loop phase response over the entire audio range) of the low-feedback designs.

The unit I chose to modify—the BES model 850, forerunner of the mostly cosmetically improved Streets 950*—originally had the same problem. Initially, I applied my POOGIE concepts (*TAA* 1/81, p. 20; 4/81, p. 7), used regulated supplies and carefully matched the complementary devices. These changes reduced THD to 0.25 percent at 20kHz, 1dB below clipping. This distortion level remained fairly high at lower power levels.

I then analyzed the operating currents and design of the original Leach circuit from output to input. By operating the devices in a more linear manner, I was eventually able to achieve distortion levels 30 times lower (0.008 percent at 20kHz, 1dB below clipping) than my initial changes produced. Distortion decreased as I reduced the power level.

I also cleaned up a ground-loop problem that had prevented the THD from being as low as possible. Once I did this, the "haze" around the musical instruments disappeared, revealing the finer details of the sound.

My changes in the original design appear in *Fig. 1*. As you can see, the improved performance did not result from my increasing the amount of overall (loop) feedback. High-feedback designs do have certain advantages, especially in production. These include the following: no need to reduce THD by using expensive matched devices; reduced unit-to-unit variations; minimized aging effects of components (especially tubes); and the ability to correct high distortion from a nonlinear stage with large amounts of feedback. Still, improving open-loop performance is more beneficial in audio. Is it possible that designing amplifiers to be very linear has become a lost art? This approach was popular around 1977, and Don Prock's "Showcase" feature on Leach's follow-up design (*TAA* 1/84, p. 43) inspired me to dust off my modification and pass it along to you.

Don't be misled by recent efforts to identify other sources of amplifier colorations (such as grounding, wiring, "passive" components, low and constant-Z power supplies, topology interactions, slew-induced distortion and passive RIAA) not generally detected by conventional "static" distortion measurements such as THD. However important these factors are, they can be masked by high levels (greater than 0.1 percent) of static THD. There is no good reason why low-feedback designs must

have much worse THD levels.

Motional Feedback

Prior to reworking this design, I tried reducing loudspeaker distortion by including the speaker in the amplifier feedback circuit. This was back when the Dyna Stereo 120 was a popular, new amplifier. By passing the speaker current through a small resistance and placing that resistance in series with the Stereo 120's feedback resistor to ground, I could provide a form of motional feedback control. The results of this experiment are shown in *Figs. 2-4*. Measurements were taken with an HP 331A distortion analyzer. Even though I experimented with the technique in this low-feedback design (Mr. Streets included this simplified form of motional feedback after I described my results), I think it is best when used only for low frequencies (biamped triamped systems) and with high-feedback amplifiers.

I did not try to find out how low loudspeaker THD would go. It might be fun to revitalize motional feedback, which began in the tube era, for specific applications. Modern voltage amplifiers driving moving-coil loudspeakers work successfully on the assumption that the impedance is roughly constant over the entire frequency range. This, however, is not the case, and al-

* The January 1985 issue of *Audio* includes a review of the Streets model 950 amplifier. Apparently, proper ground layout was not maintained, as crosstalk measured only 46.7dB at 20kHz. Distortion was worse, too, but still under 0.1 percent, which is very good for a low-feedback circuit. I suspect the ringing shown is a clue to the regulated power supply, as neither the Leach nor the Streets 850 had this problem. Proper construction techniques such as grounding and wiring are just as important as the design.