AMPLIFIER HAVING ULTRA-LOW DISTORTION

TECHNICAL FIELD

This invention relates to amplifiers and in particular relates to an arrangement of an amplifier and to a method of amplification which provides improved accuracy of the amplification.

BACKGROUND ART

Most amplifiers consist of three stages:

1. An input stage, normally a differential voltage to current converter stage, in which current variations are relatively small;
2. followed by an intermediate stage whose output may produce large voltage variations and about which the amplifier's dominant pole is often formed;
3. which is then followed by an output stage most often in the form of a voltage follower.

All three stages produce distortion which affects the signal to be amplified, the output stage usually being the worst.

Throughout this specification the following descriptions are used:

The input signal to the amplifier is termed an "amplifier input signal" and is supplied to an "amplifier input", which is used to denote the input of an "input stage" adapted to amplify the amplifier input signal and to provide a "first signal."

The first signal is fed to a next stage, termed an "intermediate stage" which is adapted to amplify the said first signal and further adapted to provide a "second signal." The second signal is fed to an input of an "output stage" adapted to amplify the said second signal and further adapted to provide an "amplifier output signal" to an "amplifier output."

A "power supply means" is adapted to provide power to the input stage, the intermediate stage and the output stage.

A review of the current state of the art in low distortion has been given by D. Self in a series of articles in "Electronic World+Wireless World" from August 1993 to January 1994. In these articles distortions in each of the three stages as set out above are described and current best methods for achieving low distortion are discussed.

The D. Self articles discussed above recommended that the first stage is a differential voltage to current converter, followed by an intermediate stage about which the dominant amplifier pole is formed. This intermediate stage is a cascade amplifier feeding a constant current source so that distortion from the well known "Early effect" is avoided. Buffer transistors are inserted between the output transistors and the intermediate stage. The lowest distortion is achieved by using a symmetrical complementary bi-polar transistors in the output stage, where the one half is a driver-npn-cum-power-pnp pair configured with a large measure of local negative feedback and the other half is similarly a driver-pnp-cum-power-npn pair configured with a large measure of local negative feedback. The Self articles also recommends and teach certain circuit layouts so that spurious sources of distortion causing mechanisms may be avoided.

The lowest combination of distortion as taught by those articles gives a total harmonic distortion of about 10 parts per million (10 ppm) at 1 kHz and a little over 100 ppm at 20 kHz. However this was measured in a amplifier of very modest power, namely 10 watts. These figures are thought to be consistent with the best state-of-the-art low distortion amplifiers presently commercially available and possible from currently known techniques.

DISCLOSURE OF THE INVENTION

In accord with the teaching of this invention an amplifier has been built that achieves significantly less distortion than hitherto known and in one preferred embodiment achieves less than 1 ppm distortion at 20 kHz and an unmeasurable rating by current instruments at 1 kHz, but which is certainly less than 0.3 ppm and probably less than 0.1 ppm. This has also been achieved at high powers (up to 400 watts) as compared with the powers used by D. Self, and using a B-class MOSFET output stage. Both of these factors normally result in higher distortions compared to that attainable at lower powers, and especially with the bipolar output transistors, or A-class amplifiers regardless of the output devices used.

This invention achieves this by teaching a different topography in all three stages to achieve an approximately two orders of magnitude improvement.

Therefore in one form of the invention there is proposed an electronic amplifier apparatus comprising of an input stage, to which an amplifier input signal is applied and which is adapted to amplify the amplifier input signal and to provide a first signal to an intermediate stage adapted to amplify the said first signal and further adapted to provide a second signal to an output stage adapted to amplify the said second signal and further adapted to provide an amplifier output signal to an amplifier output and a power supply means adapted to provide power to the input stage, the intermediate stage and the output stage, wherein the output stage including output transistors connected so as to provide the amplifier output signal and further including an error correction means comprising of an input buffer means, an adding means, a subtracting means and a voltage follower buffer means wherein, the said adding means is adapted to sum the second signal with a difference signal to produce an output sum signal, the said voltage follower buffer means is adapted to provide a buffered output sum signal when fed the output sum signal, the buffered output sum signal is fed to inputs of the output transistors and to the subtracting means, the amplifier output signal is fed to the subtracting means which is adapted to subtract the amplifier output signal from the buffered output sum signal to produce the difference signal, and a first bootstrapped power supply is adapted to provide power to the error correction means, the first bootstrapped power supply further adapted to closely track the output signal by means of bootstrapping.

Preferably all transistors in the error correction means are small signal transistors.

Preferably the second signal is also fed to a constant current source whose power is supplied by the said first bootstrapped power supply means which is further adapted to provide power to the constant current source, the constant current source containing a constant current supply transistor which is a small signal transistor.

Preferably the bootstrapped power supply means has little distortion and has local negative feedback.

Preferably the output buffered sum signal is substantially independent of temperature.

Preferably said voltage follower buffer has substantially high input impedance, low output impedance, low distortion and negative feedback localised to the said voltage follower buffer.

Preferably the said voltage follower buffer has substantially high input impedance, low output impedance, low