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An Overview of Common Techniques for Power Amplifier Linearization

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Here is a brief review of the major techniques for improving power amplifier linearity, with an extensive reading list for additional study on topics of interest

The subject of power amplifier linearization is much more complex than a basic tutorial article can cover. However, this note will serve as a reminder of the primary methods used to enhance linearity. Also, we have provided an extensive Bibliography that can be used for further research on particular methods.

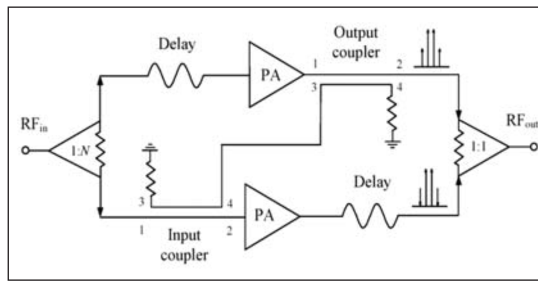

Figure 1 · Block diagram of the cross-cancellation technique.

Important Methods for Linearization

Class A operation—Biasing a power device for conduction in its linear region over the entire swing of the input signal waveform provides linear operation, but with low efficiency. When power consumption, size, weight and thermal considerations can be accommodated, a class A amplifier can be an effective solution.

Feedback—Sampling a portion of an amplifier's inverted waveform output, then summing it with the input, partially cancels distortion products. Gain is reduced, and the time delay introduced by the feedback signal path may limit the upper frequency range.

Feedforward methods—Like feedback, there is a cancellation of the distorted output signal, but without the time delay of re-introducing an output sample at the input. Instead, there are two signal paths, one of which is highly linear, and carries a sample of the undistorted input signal. This signal is compared with a sample of the main signal path output, resulting in an error signal consisting (ideally) of only distortion products. This error signal is inverted and summed with the output signal, cancelling some of the distortion products. Delays are introduced to match the main signal and the error channels. There are numerous methods and topologies for acquiring the output sample, taking the difference with the undistorted signal, and recombing the error signal with the distorted output.

Cross-cancellation—This might be considered a hybrid of feedback and feedforward techniques. The input signal is divided, then amplified by two identical power amplifiers. Feedback is obtained from the output of one amplifer, but introduced to the input of the opposite amplifier. Because the sampled and corrected signal paths are separate, delays can be introduced at the input of one and the output of the other, eliminating the time difference between the through and feedback signals (see Fig. 1).

Analog Predistortion—Linearity can be improved in some systems by implementing a piecewise approximation of an amplitude transfer function that is opposite that of the nonlinear amplifying device. The degree of improvement is limited by the accuracy and stability of the circuitry.

Digital predistortion—A sample of the output can be routed to a fast signal processor that calculates the necessary correction to the transfer function. Speed must be sufficient to update the correction as operating parameters change due to thermal effects, aging, duty cycle and output power level. This method is being extensively used, and steadily improved, in current wireless systems.

Linearity by design—There are also amplifier circuits such as the Doherty method, outphasing, and combined polar/amplitude modulation that have greater inherent linearity, at the cost of increased complexity. These are not linearization techniques per se, but do result in an amplifier with greater linearity than traditional designs.

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