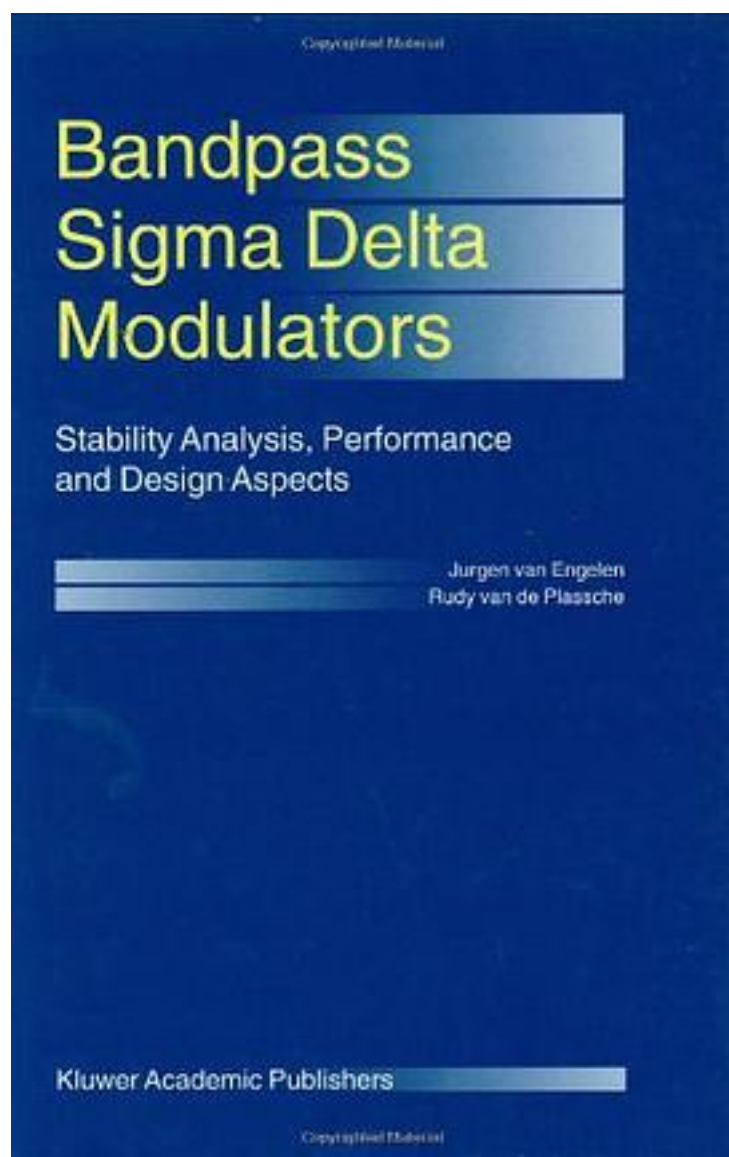


Bandpass Sigma Delta Modulators



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Sigma delta modulation has become a very useful and widely applied technique for high performance Analog-to-Digital (A/D) conversion of narrow band signals. Through the use of oversampling and negative feedback, the quantization errors of a coarse quantizer are suppressed in a narrow signal band in the output of the modulator. Bandpass sigma delta modulation is well suited for A/D conversion of narrow band signals modulated on a carrier, as occurs in communication systems such as AM/FM receivers and mobile phones. Due to the nonlinearity of the quantizer in the feedback loop, a sigma delta modulator may exhibit input signal dependent stability properties. The same combination of the nonlinearity and the feedback loop complicates the stability analysis. In Bandpass Sigma Delta Modulators, the describing function method is used to analyze the stability of the sigma delta modulator. The linear gain model commonly used for the quantizer fails to predict small signal stability properties and idle patterns accurately. In Bandpass Sigma Delta Modulators an improved model for the quantizer is introduced, extending the linear gain model with a phase shift. Analysis shows that the phase shift of a sampled quantizer is in fact a phase uncertainty. Stability analysis of sigma delta modulators using the extended model allows accurate prediction of idle patterns and calculation of small-signal stability boundaries for loop filter parameters. A simplified rule of thumb is derived and applied to bandpass sigma delta modulators. The stability properties have a considerable impact on the design of single-loop, one-bit, high-order continuous-time bandpass sigma delta modulators. The continuous-time bandpass loop filter structure should have sufficient degrees of freedom to implement the desired (small-signal stable) sigma delta modulator behavior. Bandpass Sigma Delta Modulators will be of interest to practicing engineers and researchers in the areas of mixed-signal and analog integrated circuit design.

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