
Preface

This book presents the design of a high dynamic-range (DR) continuous-time (CT) IF-to-baseband $\Sigma\Delta$ modulator for AM/FM receivers. The main challenge of this work was to achieve 118dB DR in 3kHz (AM mode) and 98dB DR in 200kHz (FM mode). At the same time, high linearity ($IM_3 > 85\text{dB}$) was required to allow multi-channel digitization in AM mode. The designed ADC also complies with the IBOC (In-Band, On-Channel) standard for digital audio broadcast.

In Chapter 2, an overview of the most important radio receiver architectures is presented. The evolution of CMOS technology enabled the incorporation of digital signal processing into car radios. The closer the ADC is to the antenna; the more signal processing functions like filtering and demodulation can be implemented in the digital domain. As a result, more resolution and linearity are demanded from the ADC. The most important ADC performance metrics, and concepts like desensitization, blocking and image rejection are also reviewed in this chapter

Chapter 3 starts with a review of the basic principles of CT $\Sigma\Delta$ modulation: oversampling, noise shaping and intrinsic anti-alias filtering. The stability and the tonal behaviour in high-order loop filters are also discussed. Non-idealities in the modulator implementation may cause down-conversion of strong tones and quantization noise from nearby $f_s/2$ to the low-frequencies, reducing the modulator DR. This chapter ends with a discussion about the effects of clock jitter in the performance of CT $\Sigma\Delta$ modulators.

A discussion about $\Sigma\Delta$ ADC topologies for DSP based radio receivers is presented in Chapter 4. The major characteristics of lowpass, IF-to-baseband, quadrature IF-to-baseband, bandpass and quadrature bandpass $\Sigma\Delta$ ADCs are compared. An IF-to-baseband $\Sigma\Delta$ ADC consists of a mixer integrated with a lowpass modulator for IF digitization. Two IF-to-baseband ADCs in parallel, whose mixers are driven in quadrature,

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implement a quadrature IF-to-baseband ADC. It is shown in Chapter 4 how mismatches among the complex integrators' building blocks translate into the leakage of quantization noise power from the image band to the signal band, and vice-versa. Finally, a comparison among these architectures is presented.

Chapter 5 describes the system-level design and the circuit implementation of a single-bit 5th-order quadrature CT IF-to-baseband $\Sigma\Delta$ ADC for AM/FM/IBOC receivers. This 118dB DR ADC enables the realization of a car radio that does not require an IF VGA, neither an AM channel selection filter. Because of the multi-channel AM digitization, most of the AM channel selection can be performed in the digital domain.

Finally, Chapter 6 presents the conclusions of this work and a discussion about the economic feasibility of the proposed radio receiver architecture. This book ends with two appendixes. In appendix A, an analysis of the harmonic distortion in CT integrators employing MOSCAPs is presented. The input-referred noise of CT $\Sigma\Delta$ modulators with switched-capacitor feedback is calculated in Appendix B.

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