ANALYSIS AND SYNTHESIS OF MOS TRANSLINEAR CIRCUITS

ANALYSIS AND SYNTHESIS OF MOS TRANSLINEAR CIRCUITS

by

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To Cisca
and my parents

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Foreword

This book has its roots in an idea first formulated by Barrie Gilbert in 1975. He showed how bipolar analog circuits can realize nonlinear and computational functions. This extended the analog art from linear to nonlinear applications, hence the name translinear circuits. Not only did this new principle enable marvellous signal processing functions to be accurately implemented, but also the circuits were simple and practical. The perennial problems of analog IC design, namely temperature sensitivity, processing spread, device nonlinearity and paracitic capacitance were solved to a large extent.

Using the translinear principle in circuit design requires changing your point of view in two ways. First, the grossly nonlinear characteristic of transistors is viewed as an asset rather than as a harmful property. Second, no longer are the signals represented by voltages, but by currents. In fact, the attendant voltage changes are distorted but, as they are very small, they are only of secondary interest.

Understanding and analyzing a given translinear circuit is fairly straightforward. But what about the converse situation: suppose you're given some nonlinear or computational function to implement? How to find a suitable translinear circuit realization? The general problem of analog circuit synthesis is a difficult one and is receiving much attention nowadays. Some years ago, I had the opportunity to investigate methods for designing bipolar translinear circuits. It turned out that translinear networks have some unique topological properties. Using these properties it was possible to establish heuristic synthesis procedures.

In this book, Wiegerink extends translinear circuit design to MOS-technology. The square-law characteristic of MOS transistors operated in the saturated region is exploited. This results in nonlinear signal-processing functions different from those provided by bipolar translinear circuits which are based on the exponential current-voltage characteristic. Also different is the quality of function implementation. Bipolar circuits maintain precision over a larger dynamic range. However, this is offset by the fact that MOS-technology is the dominant industry driver.

The book starts by deriving the MOS translinear principle and investigating the effects of transistor nonidealities. Next, a systematic approach to analysis is developed based on a graphical method which is easy to visualize. A significant contribution here is a computer-aided analysis program. Probably the most important part of the book concerns circuit synthesis. Design strategies are described which combine the strengths of human creativity, the insight afforded by graphical representation and computer processing power. The techniques are demonstrated by designing various useful circuits: an output stage for CMOS opamps, a four-quadrant multiplier and a variable-gamma circuit for colour television. Finally, a number of new nonlinear building blocks are presented in an appendix.

Evert Seevinck

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Remco Wiegerink