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Ph.D. Topic: Design of CMOS compatible Analog Circuits for Signal Processing/ Generation Applications

ABSTRACT

This thesis deals with the 'Design of CMOS Compatible Analog Circuits for Signal Processing/Generation Applications.

Because of wide spread emphasis on operational transconductance amplifiers (OTAs) and transconductance (g_m) based circuits due to their suitability for complete integration in Bipolar, CMOS or Bi-CMOS technologies, the work reported in this thesis is focused on presenting new ideas related to Analog Signal Processing /Generation circuits using OTA-C networks only. In view of this, it is, therefore, pertinent to present a survey of the evolution of OTAs, their implementations and their applications in analog signal processing (limited to filters) and signal generation circuits (limited to sinusoidal oscillators), to put the contents of this thesis in right perspective.

Chapter 1 discusses the evolution and significance of OTA-C and g_m-C circuits, traces the development taken place in the design of Bipolar, CMOS and Bi-CMOS OTAs and transconductors; presents a review of earlier work done on OTA-C oscillators and filters and outlines the scope of the research work reported in this thesis.

Chapter 2 of the thesis deals with the systematic derivation and realization of single OTA-RC as well as dual OTA-RC sinusoidal oscillators. In the earlier literature, it has been shown that corresponding to a given single-operational trans-conductance amplifier (single-OTA)-RC and dual-OTA-RC sinusoidal oscillators, there are three other structurally distinct equivalent forms having the same characteristic equation, one of which employs both grounded capacitors (GC). In this study, an earlier nullor-based theory of generating equivalent op-amp oscillator circuits is extended to derive equivalent OTA-RC circuits which discloses the existence of an additional number of equivalent forms for the same given OTA-RC oscillators than those predicted by the quoted earlier works, and thereby considerably enlarging the set of equivalents of a given OTA-RC oscillator. Furthermore, the presented nullor-based theory of generating equivalent OTA-RC oscillators results in three additional interesting outcomes: (i) the revelation that corresponding to any given OTA-RC oscillator there are two 'both-GC' oscillators (and not merely one, as derived in the quoted earlier works); (ii) the

availability of explicit current outputs in several of the derived equivalents and (iii) the realisability of explicit-current-output ‘quadrature oscillators’ in some of the generated equivalent oscillators. The workability of the generated equivalent OTA-RC oscillators has been verified by SPICE simulations, based on CMOS OTAs using 0.18 μm CMOS technology process parameters, and some sample results are given.

Chapter 3 contributes OTA-C Sinusoidal oscillators, which are useful for implementation in both bipolar and CMOS technologies due to the complete absence of passive resistors, requirements of only OTAs and integratable MOS capacitors in their design with the advantageous feature of providing electronic tunability of the oscillation frequency through external current/voltage signal. In particular, the oscillator circuit topologies which employ a minimum number of OTAs (no more than three) along with a minimum number of capacitors (no more than two), along with both capacitors being grounded, are particularly attractive from the view point of IC implementation. Thus, it has been shown that how, starting from various known three-OTA-C oscillators, even if they may not be employing both grounded capacitors, new three-OTA-grounded-capacitor (TOGC) versions can be derived systematically using a theoretical framework based upon nullors. The workability of the new TOGC oscillator configurations has been confirmed by SPICE simulations based upon CMOS OTAs using 0.18μm CMOS technology process parameters and some sample results have been presented.

Chapter 4 of the thesis deals with the current mode biquads employing OTAs and grounded capacitors. In this Chapter, we have realized the multiple-input-single-output (MISO) and single-input-multiple-output (SIMO) type biquads. Here, we have presented MISO-type biquad using three OTAs and two current followers and a SIMO-type biquad employing two OTAs and one current follower. Both of the proposed circuits realize the current mode universal filters. The workability of the proposed circuits has been demonstrated by SPICE simulation results based upon CMOS OTAs and current follower implementation using 0.18 μm CMOS technology.

The last Chapter of the thesis summarizes the work presented in the thesis. Besides this, a number of suggestions for further work have been made.