ABSTRACT

This thesis presents a detailed investigation into the synthesis, analysis and design of novel current-mode (CM) continuous-time (CT) filters using versatile analog building blocks like dual-output operational transconductance amplifiers (DO-OTAs) and multiple-output operational transconductance amplifiers (MO-OTAs). The research investigation presented in this thesis will also include phase compensation of operational transconductance amplifier (OTA) based Active-RC filters to improve the frequency response. The investigation of compensation of current feedback operational amplifier (CFOA) based inverting amplifier to extend bandwidth and/or to improve the phase response has also been presented.

A novel synthesis procedure is proposed to realize new first-order, second-order and high-order current-mode all-pass filters using a general DO-OTA based two-admittance circuit configuration using OTAs with one or two current output(s) and with (or without) grounded capacitors. Two first-order current-mode all-pass filters and amplitude equalizers that have been obtained are presented. Two current-mode second-order all-pass filters are shown to be obtained by using operational transconductance amplifier-capacitance (OTA-C) simulated inductances in the basic first-order structure. The non-ideality analysis of first-order and second-order all-pass filters is presented. The high-order all-pass filter circuits based on the first-order structure are shown to be realized using OTA-C simulated ladder sections. The realization of second-order quadrature oscillator using MO-OTAs and grounded capacitors, using two first-order all-pass filter sections, is also considered. The proposed DO-OTA-C circuits have been simulated using Cadence Virtuoso, Spectre Circuit Simulator and PSPICE. The experimental results obtained by considering a discrete implementation of the second-order current-mode DO-OTA-C all-pass filter circuit using CA3080 bipolar OTA ICs have been presented.

Four current-mode multi-function biquads have been realized using OTA-C simulated inductances in the general DO-OTA based first-order topology with two equal input currents. Two universal biquads have been shown to realize all of the usually needed second-order current-mode transfer functions and some impedance transfer functions. Two biquad circuits
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that realize high-pass notch (HPN)/ high-pass (HP) and low-pass notch (LPN)/ low-pass (LP) current-mode transfer functions have been presented.

The current-mode OTA-C universal biquad filter structure based on Moschytz’s modified Tarmy-Ghausi (TG) Active-RC filter and novel techniques to reduce the $Q_p$-sensitivity are presented. Further, a new synthesis procedure to realize all generally needed biquadratic transfer functions based on summation of appropriate combination of feed-forward coefficients by invoking the analogy with direct-form digital filter structure is presented. Two new current-mode second-order all-pass filter circuits, using a common coefficient to implement numerator as well as denominator coefficient, derived from Mitra-Hirano and Gray-Markel lattice digital filter structures have been presented.

This thesis also presents results of the investigation regarding the phase compensation of OTA-based Active-RC filters using feed-forward compensated opamps. The exact analysis for the passive compensation of lossless integrator and lossy integrator used in Active-RC filters taking into account the finite output resistance and capacitance of the OTAs has been presented. It has been shown that the use of a negative resistance and negative capacitance at the input of the composite $g_{m}$-cell, will provide exact compensation for both the lossy and lossless integrators with OTAs that do not need any parallel feed-forward path. Three novel DO-OTA based negative capacitance realization circuits, needed for the phase compensation, have been reported in the thesis.

The problem of extending bandwidth of CFOA-based inverting amplifier has been addressed, and three techniques have been investigated based on the well-known techniques used in the active and passive compensation of opamp based finite gain inverting amplifiers. The use of negative impedance converter (NIC) at the inverting input of the CFOA has been studied. The isolation of the inverting input of the CFOA from the junction of input and feedback resistors using voltage buffer has also been studied in order to exploit the high inherent bandwidth of the CFOA. The use of two CFOAs in feed-forward mode following the two-opamp based finite gain amplifiers also has been investigated. The use of feed-forward capacitor for reducing the phase error has been investigated for these configurations.