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Ph. D. Thesis Title: Signal Processing/Signal Generation Circuits Suitable For Analog VLSI Using Operational Transresistance Amplifiers (OTRAs)

ABSTRACT

Recently, current-mode signal processing circuits have gained potential advantage over voltage-mode signal processing circuits as they can exhibit under certain conditions higher bandwidth and better signal linearity. Current-mode signal processing circuits are designed for lower voltage swings; therefore they require low supply voltages. The current-mode techniques have been given way to a number of important analog signal processing/signal generation circuits, as is evident from a vast amount of literature on current-mode circuits and techniques published. Thus, it can be concluded that the current-mode approach to signal processing offers one or more of the following advantages: Higher frequency range of operation, lower power consumption, higher slew rates, improved linearity and better accuracy. During the last two decades, a large number of current-mode building blocks have been proposed such as current-feedback operational amplifier (CFOA), operational transconductance amplifier (OTA), current-differencing buffered amplifier (CDBA), current-differencing transconductance amplifier (CDTA), four terminal floating nullor (FTFN) and operational transimpedance amplifier popularly known as operational transresistance amplifier (OTRA). All the above mentioned building blocks have been used by a large number of researchers to provide analog functional circuits suitable for VLSI implementations along with digital circuits on the same chip. Apart from the above mentioned building blocks, a large variety of current conveyors such as third generation current conveyors, differential voltage current conveyors, inverting current conveyors and fully differential current conveyor along with their CMOS implementations and various applications have also been advanced. First in the thesis we present an overview of the hardware as well as various CMOS implementations of Operational Transresistance Amplifier (OTRA) structures available in the literature. Then we review different signal processing/signal generation circuits implemented using OTRAs namely all pass filters, universal filters, Tow-Thomas and KHN filters, biquadratic filers and MOSFET-C filters, sinusoidal, quadrature and multi-phase oscillators, immittance simulators and their application examples, waveform generators (both in voltage-mode and current-mode) and various other applications such as proportional-derivative controller, analog multipliers and their applications, transimpedance instrumentation amplifier and voltage-mode pulse-width modulator. Next in the thesis we have presented simulation of grounded inductors, grounded frequency

dependent negative resistance (FDNR) and simulation of generalized impedances using OTRAs. As an application example the simulated immittance were used for the implementation of single-resistance controlled oscillator (SRCO) and single-capacitance controlled oscillator (SCCO). Also, the non-ideal analysis was carried out for the various circuits to demonstrate the effect of parasitic capacitance, input resistance of the input terminal of the OTRA and its output resistance. To check the practical validity of the various realized generalized impedances different application examples have been given. The grounded inductor was used to simulate a second-order passive RLC band pass filter circuit, grounded FDNR was validated through realization of a second-order passive RCD low pass filter circuit, the RVC was used to simulate a first-order passive RC low pass filter and the grounded FDNC was tested as a resonator. Also, the non-ideal analysis of the proposed generalized impedances was carried out by considering the parasitic capacitance and the output resistance of the OTRA. Next contribution in the thesis is on the realization of family of state-variable RC and MOSFET-C sinusoidal oscillators using OTRAs. In this chapter systematic derivation of OTRA based RC oscillators as well as MOSFET-C based oscillator circuits have been presented, the kind of which have not been reported in the literature earlier. The workability of the proposed circuits was verified both by hardware implementation and SPICE simulation that establishes the practical validity of the proposed configurations. Chapter-4 of the thesis deals with the non-ideal one pole and two pole models of the transresistance gain (R_m) of the OTRA. In this chapter we have explicitly used the OTRA-pole in evolving external capacitor-less, active-R circuits which have not been investigated in literature earlier. Here we have presented three OTRA-based active-R circuits which realize an inductor, an oscillator and a low-pas/band-pass filter respectively. The proposed circuits have the novel feature of employing a low number of total components and offer a number of other advantages. The workability of the proposed circuits has been demonstrated by SPICE simulation results based upon CMOS-OTRA implementation using 0.5μm 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.

Keywords: Operational Transresistance Amplifier (OTRA), Immittance Simulator, SRCO, SCCO, Generalized Impedance Simulator, Filters, Active-R Circuits.