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Title of the Thesis: Analog Signal Processing Circuits using Modern Building Blocks

ABSTRACT

This thesis deals with a class of analog signal processing circuits (continuous-time filters and oscillators) using modern building blocks. The thesis presents the results of investigation for devising various signal processing /signal generation circuits in voltage-mode (VM), current-mode (CM) and mixed-mode operations. Although a large variety of analog building blocks have been used in earlier technical literature, we have focused on two of the most versatile and widely used building blocks namely, the current conveyors (and their variants namely the first generation and second generation current conveyors (CCI, CCII), DOCCs, MOCCs, FDCCIIs) and operational transconductance amplifiers (OTAs) which have been widely used in recent analog circuits literature.

The thesis begins by presenting a brief introduction and survey of some prominent current mode building blocks, which have been finding prominent attention in the area of analog signal processing. Some exemplary hardware implementations of a selected number of building blocks such as op-amp, OTA, CCI, CCII, FTFN, DDA, CFOA, CCIII, DDCC, DOCC, MOCC, DVCC, ICCII, FDCCII, OTRA, CDBA and CDTA have been reviewed. In the last, an outline of the research work reported in this thesis has been provided.

After this, the realization of multiple input single output (MISO) current mode (CM) universal biquad filters has been dealt with alongwith a critical survey of a number of CM universal biquad filter circuits known earlier. A new MISO-type CM universal biquad circuit using multiple output second-generation current conveyor (MO-CCII) has been introduced. This configuration is an important new addition to the existing repertoire of CC-based biquads. The proposed new circuit realises all the five current mode filters using grounded capacitors, without requiring any component matching conditions. SPICE simulations have established the workability of the circuit. The stability of the filters of the proposed circuit has also been established.

Next, the synthesis of explicit output single resistance controlled oscillator (SRCO) in current-mode has been presented in this chapter 3. In this chapter, a new explicit current output SRCO circuit has been proposed using first generation current conveyor (CCI) and CCII. The new circuit has been compared with some of the previously reported oscillator

circuits using current conveyors and its advantages have been brought out. The proposed configuration enjoys independent control of both CO and FO. The frequency stability factor has been derived and it has been found that in this respect the proposed circuit is at par with or better than most of the classical oscillators (such as Wien bridge, RC phase shift etc.). Monte-Carlo simulations are used to check and establish the robustness of the proposed circuit.

The next contribution of this thesis (in chapter 4) is introduction of electronically controllable explicit current-output second order sinusoidal oscillators using MO-OTAs and grounded capacitors. After reviewing the state of the art of OTA-C oscillators, five new current-mode electronically controllable OTA-C oscillator configurations with explicit current mode output have been presented. All the proposed circuits enjoy the feature of independent controllability of oscillation frequency and condition of oscillation. Also, all the proposed circuits provide quadrature outputs as an additional feature. PSPICE simulations have established the workability of the proposed circuits. The robustness for all these configurations too has been checked and verified by Monte-Carlo simulations.

In chapter 5, we have introduced a very simple yet previously undisclosed state variable method of converting SRCOs into universal CM biquads. Through this method, any given single resistance controlled oscillator (SRCO) can be re-configured as a multiple-input-single-output (MISO) -type current-mode (CM) universal biquad. Although the method to convert a SRCO into universal current-mode biquad proposed here might appear simple but it has not been explicitly published in the open literature earlier. Also, although the fully differential second generation current conveyor (FDCCII) based development is used as an example, the proposed method is fairly general and can be applied to other SRCOs also to generate new multifunction filter structures. To substantiate this assertion, two more examples have been presented to convert CCII-based SRCO into MISO-type CM biquads.

A new multiple input multiple output (MIMO)/ single input multiple output (SIMO) mixed mode (VM and CM) filter configuration has been presented in chapter 6. The new MIMO/ SIMO mixed mode universal biquad has been implemented using dual output current conveyors (DOCCs). The mixed mode quadrature oscillator can also be realized from the same configuration with the simple artifice of modifying a circuit connection. The SIMO-type CM biquad enjoys independent tunability for cut-off frequency and bandwidth. The stability of the proposed filters has also been tested and established. The new circuit has been compared with some of the previously reported continuous-time filter circuits using current conveyors and has been shown to possess features all of which are not available simultaneously in any of the previously known configurations.

Finally, conclusions of this thesis are made in chapter 7, which also suggests some ideas for future research.