CHAPTER 1 INTRODUCTION

1.1 Overview

Continuous–time (CT) active filters are active networks (circuits) with many capable characteristics that make them useful in today's system design [1]. In communication systems, the processing of a signal is accomplished in a single or a set of a mixed-signal IC. Mostly implemented based on CMOS technology, these ICs usually contain digital functions, A/D and/or D/A. The signal conversion parts, A/D and D/A, usually require the continuous-time (CT) bandpass filter especially in high-frequency applications. However, the CT circuits usually require passive resistors and capacitors, which are not favorable to be embedded in an IC as they require a very large chip area compared to MOSFET transistors. In addition, a novel CMOS process generally provides only NMOS and PMOS devices, rarely allowing the use of polysilicon resistors or high-density linear capacitors [2]. Therefore, a few years are the approximate time to add such modules to the technology, which virtually pushes an analog process behind a digital process. Unfortunately, the digital IC tends to move forward with the new technology as soon as possible. Therefore, analog applications integrated in the same chip must follow.

The requirements of passive resistors can be reduced significantly by utilizing the applications that are based on electronically tunable active devices, which are able to simulate variable passive resistors by adjusting a bias condition. One of the most favorable devices of this type is the operational transconductance amplifier (OTA), which is actually the voltage-controlled current source, whose conductance can be tuned electronically by adjusting a bias current. Therefore, a lot of resistorless OTA-based applications are introduced, which are usually composed of OTAs and passive capacitors, which are famously called OTA-C or g_m-C applications.

Regularly, CT active filters are implemented based on a BIQUAD circuit or simply BIQUAD, which the second-order circuits provide operations of the CT filters such as lowpass, bandpass, and etc. As the OTA is very famous, various integrator-loop OTA-C BIQUADs are proposed [1] in both voltage and current modes. Though these BIQUADs are usually unique and attractive, the presence of a capacitor is still unfriendly to an IC. Interestingly, a capacitorless oscillator [3] and a related circuit [4] utilizing parasitic capacitance of transistors are reported. As other active devices, the OTA is also suffered from nonidealities including the parasitic capacitance [1], which is usually absorbed by a desired circuit's capacitor. If these parasitic capacitances can be utilized effectively, capacitorless OTA-based BIQUADs may be exceedingly available by simply removing the capacitors of the existing OTA-C BIQUADs. However, the properties of these parasitic elements are very hard to be expressed mathematically, which virtually close the opportunity to synthesize the transfer function of an OTA-based capacitorless BIQUAD. As there is no adequate transfer function, the utilization seems impossible.

Therefore, in the previous work [5, 6], the Genetic Algorithm (GA) and the Artificial Neural Network (ANN) [7] are utilized to practically tune the bandpass response of an OTA-based capacitorless BIQUAD. Though the obtained solutions are acceptable, the GA takes very long time per BIQUAD's specification [5]. The ANN-based tuning finishes at almost instant but with a cause of extremely long training time and the significant deviation of the tuned response [6]. Therefore, in this work, the ANN is sequentially trained with an updated small training set consisting of a few of ten bias points which are close to the specified BIQUAD parameters. The updated training set occurs if and only if the trained ANN provides a solution that is not satisfied but better than the worst bias point in the presence of the training set. Through several updates and training, the ANN is supposed to provide an acceptable solution. By limiting sizes of the training set, the complexity of the ANN is significantly reduced and the training time greatly decreases. Though there may be several response generations and evaluations, its amount is far less than the minimum required by the GA.

1.2 Objectives

Utilize the instant trained ANN to tune the behavior of a capacitorless bandpass BIQUAD.

1.3 Scopes of this Thesis

1. The design is based on MOSFET.
2. The based OTA is a simple single-stage CMOS OTA.
3. The experiments are conducted via the HSPICE simulations based on the AMS's 0.35µm CMOS process.
4. The evaluated responses are collected from HSPICE.
5. The prototype system is implemented on the ANN toolbox of the MATLAB.

1.4 The Proposed Procedures

1. Study the principles of BIQUAD.
2. Study the fundamentals of the ANN.
3. Select the based OTA-C BIQUAD.
4. Modify the selected OTA-C BIQUAD by removing its dominated capacitors.
5. Select the appropriate ANN structure.
6. Specify and collect training information.
7. Train specific ANNs and observe results.
8. Verify obtained feasibility and tuning.
9. Draft recommendations on an appropriate ANN based on experiments.

1.5 Outline of this Thesis

This Thesis consists of six chapters: the first provides background and objectives, the second lists directly and indirectly related works, the third briefs fundamental theories related to the research and the fourth profoundly provides the experiment method to support this thesis including circuit structures and insightful analyses experiment designation. The fifth presents the structures experimentally based on simulations. Finally, the conclusion of this thesis is expressed in the sixth chapter.