Chapter 4
Design of Low Noise Amplifiers through Flow-Graphs and their Optimization by the Simulated Annealing Technique

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ABSTRACT

This chapter presents the optimal design of Low Noise Amplifiers (LNAs). The basic idea consists of optimizing performances of LNAs by a direct action on the scattering parameters. A symbolic approach, namely the Coates Flow-Graph technique, is used to automatically generate symbolic expressions of the impedance parameters and, thus, those of the scattering parameters. The Simulated Annealing optimization technique is applied to determine the optimal sizing of the LNA. ADS simulation results are given to show the viability of the proposed approach.

INTRODUCTION

Low Noise Amplifiers (LNAs) compose a decisive building block in any radio-frequency front-end (Razavi, 1998). According to (Friis, 1944), when using a LNA, the noise effect of all the receiver's subsequent stages is reduced by the gain of the LNA which noise is directly injected into the received signal. Accordingly, it is compulsory for a LNA to boost the desired signal power while adding as little noise

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and distortion as possible, so that the retrieval of the useful signal is possible in the following stages. The design task of such high performance circuit is tedious and time consuming. Besides, it generally relies on the designer's experience. CAD tools can considerably reduce this design time. However, a tool customized for the design of such circuits is not so far available.

Some published works have tried to contribute in this field (see for instance (Tulunay, & Balkir, 2005; Cheung, & Wong, 2006; Tulunay, & Balkir, 2004; Nguyen, Kim, Ihm, Yang, & Lee, 2004)). Main contributions have been proposed by (Tulunay, & Balkir, 2004) and (Tulunay, & Balkir, 2005).

In (Tulunay, & Balkir, 2005), the modified nodal analysis (MNA) (Ho, Ruehli, & Brennan, 1975) was used for the generation and resolution of the circuit matrix equations. In (Tulunay, & Balkir, 2004), an equation based optimization methodology was proposed. It is also based on the use of the simulated annealing heuristic. Besides, the multi-objective multi-constrains problem is transformed into a mono-objective unconstrained one.

Scattering parameters are decisive parameters in the design of LNA's since they reflect the power gain and the input and output matching of the circuit. This chapter deals with optimizing the scattering parameters via the LNA's impedances, which symbolic expressions are computed automatically using a graph approach, namely, the Coates flow-graph technique (Coates, 1959; Starzyk, & Konczykowska, 1986). Afterwards, the simulated annealing optimization technique, which is a generic probabilistic metaheuristics that is widely adopted for solving global optimization problems, is used to solve such NP-hard problem. i.e. generating the design variables' optimal values that satisfy constraints imposed on the performances' metrics (such as noise figure), and maximize objective functions (such as gain).

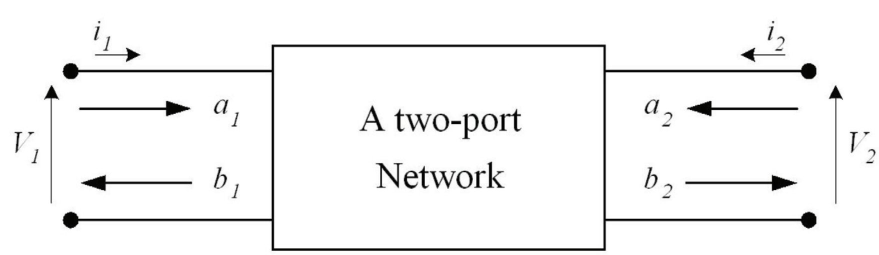
A BRIEF OVERVIEW ON THE SCATTERING PARAMETERS

The definition of the Scattering Parameters, noticed S-Parameters, is based on the theory of the incident and reflected waves (Kurokawa, 1965; Kurokawa, 1969). Thus, S-parameters describe the relationship between the different waves of a system. Figure 1 represents a network with two ports including the incident and reflected microwaves.

With (Scott, 1993):

- a_1: the electric field of the microwave signal entering the network input,
- b_1: the electric field of the microwave signal leaving the network input,

Figure 1. A two-port network with incident and reflected waves



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