Chapter 5

VHDL-AMS IN MEMS DESIGN FLOW

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Abstract: Behavioral modeling languages can be used in different steps of top-down design and bottom-up verification of MEMS design. The available language facilities of VHDL-AMS and the requirements of the applied methods in this process are confronted. Especially the application of Kirchhoffian networks to model 3D movements is taken into account. The decisions that should be done at the beginning of the modeling process are discussed. This is especially important if models from different sources shall be combined later on. Experiences using available simulation engines are presented. A micro mechanical accelerometer and an electrostatic beam actuator are investigated. Therefore a set of basic elements for MEMS simulation was created.

Key words: VHDL-AMS, MEMS, Kirchhoffian networks

1. INTRODUCTION

MEMS technology requires CAD tools for support. Modeling and simulation play an important rule in this environment [1], [2]. Compared to the design of electronic systems the development of MEMS design tools is at the beginning. But a lot of well-established ideas from EDA can be applied to MEMS design. Thus, a top-down methodology can be used to handle complex designs [3]. Behavioral modeling facilities allow to specify components of micro electromechanical systems and to simulate the specified systems. After the design or decision concerning the re-use of existing subsystems a validation of the system behavior should be done. This can also be carried out by simulation. Therefore behavioral models of the components with calibrated parameters based on the realized subsystems
must be available for the simulation. This step is usually called bottom-up verification in the electronic design flow [4].

![Diagram](image)

*Figure 1. Top-down design and bottom-up verification in MEMS design flow*

Advantages of the application of a unified behavioral description language in a MEMS design flow shown in Figure 1 are among other things the possibilities to combine models of different levels of abstraction and from different sources. One language that covers these requirements and the applied methods in the design flow is VHDL-AMS [5]. VHDL-AMS can be used to build complex analog and mixed-signal models. Differential equations, algebraic constraints and logic controls can be combined. With respect to the status of the standardization of the language and the scope of the language that is covered by commercially available tools, different implementation approaches are considered in the following.

## 2. DEPLOYED MODELING METHODS

Modeling with Kirchhoffian networks is well established in MEMS simulation [6], [7]. The fundamental idea consists in the combination of subsystem models to describe a more complex behavior. The connection points carry across and flow quantities. The across quantities describe translational displacements in a global coordinate system, rotations about global axes, and electrical voltages. The flow quantities characterize forces in the direction of the coordinate axes, torques about axes, and currents resp.