Library Development Using the VHDL-AMS Language

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Abstract: The VHDL 1076.1 standard for mixed analog/digital systems was approved by the IEEE in 1999. However, the design goal of portability of models and designs cannot be met without additional effort. We suggest some guidelines for the use of the extended language and propose the development and standardization of a package that supports multi-disciplinary modeling and a library of basic electrical models. Both will aid in the deployment and acceptance of VHDL-AMS tools in industry and academia. We offer a proposal for joint development of the standard with the Verilog-AMS constituency, to provide some interoperability between the two languages.

1. INTRODUCTION

IEEE Std. 1076.1-1999 [1] extends the VHDL language defined by IEEE Std. 1076-1993 [2] to support the description and simulation of analog and mixed analog/digital systems. The extended language defined by the two standards has informally been called VHDL-AMS.

The VHDL-AMS language allows a user to write analog, digital and mixed-signal models. However, to achieve portability of models between different tools, a set of guidelines and companion standards is necessary, similar to the IEEE 1164-1993 companion standard [3] to the VHDL 1076 language. Our goal is to identify the areas where companion standards are useful or even essential, and to demonstrate how a number of modeling problems that appear to require auxiliary standards can instead be addressed with the existing facilities of VHDL-AMS. Although our focus is on analog modeling, we assume that the reader is familiar with the VHDL language.

2. OVERVIEW OF VHDL-AMS

VHDL-AMS is a superset of the VHDL 1076-1993 language. Any legal VHDL 1076-1993 description is also legal in VHDL-AMS and gives the same simulation results, with the exception of conflicts caused by the introduction of new reserved words. The language supports the hierarchical description and simulation of digital (i.e. discrete), analog (i.e. continuous), and mixed-signal (i.e. mixed analog/digital) systems. The analog portion of the model consists of lumped elements that can be described by algebraic and ordinary differential equations (jointly called differential-algebraic equations, or DAEs). Models can have connections with conservative (i.e. satisfying, in electrical systems, KCL/KVL) and signal-flow semantics. Support is provided for electrical and non-electrical disciplines (or energy domains) at levels of abstraction ranging from the system level to the SPICE-like circuit level. The language supports flexible and efficient interactions between the event-driven, digital computation engine and the continuous, analog computation engine. Finally, support for small-signal AC and noise simulation in the frequency domain is provided.

We now describe the facilities of the VHDL-AMS language related to modeling of analog devices.

The language represents an unknown in the DAEs by a quantity. Scalar quantities must be of a floating-point type. Free quantities support signal-flow modeling and may also represent values like the power dissipated in a resistor or the charge in a capacitor. Branch quantities, which are declared with reference to two terminals, support the modeling of conservative systems. There are two kinds of branch quantities. Across quantities represent the potential difference between two terminals—in electrical systems, the voltage between two nodes. Through quantities represent the flow between two terminals—in electrical systems, the current in a branch between two terminals. Finally, source quantities describe small-signal frequency domain sources and noise sources.

Terminals support conservative connections. Any number of connected terminals form a node at which KCL (or its generalization to non-electrical disciplines) is enforced. Terminals have a nature that defines the discipline of the terminal—electrical, thermal, rotational, etc. Only terminals with like natures can be connected together. The nature also defines the types of the across quantities and through quantities incident to a terminal of that nature and the reference terminal for the discipline—in electrical systems, ground.

The equations describing the behavior of an analog model are written using simultaneous statements. Simultaneous statements support two modeling styles and two mechanisms to specify piecewise defined behavior, i.e. behavior that is different in different regions of operation. The most