Thesis Title:
Assertion Based Analysis of Mixed-Signal Systems

Abstract of the Thesis:
Assertions are formal properties which define admissible behaviors of the system. In the digital domain, assertions are widely used for the verification and debugging of large integrated circuits. In view of the increasing complexity of Analog and Mixed Signal (AMS) systems, assertion based verification of mixed-signal systems has become an important requirement. Several research groups, like the SystemVerilog AMS Working Group of Accellera, have included AMS assertions as one of their primary goals. The major contribution of this thesis is to develop methodologies and tools that can be used for assertion based analysis of AMS systems. The primary contributions are as follows:

1. This thesis presents the challenges of monitoring AMS assertions in general with specific focus on enriching the language for developing formal specifications. We study the use of local variables, a construct prevalent in SystemVerilog Assertion language, in AMS context. Due to the dense time interpretation of AMS assertions, a continuum of overlapping assignments to local variables is possible which dynamically generates predicates over real values (PORVs) during simulation.

2. This thesis proposes a language, called Feature Indented Assertions, to formally specify features (which are real-valued characterizing behavioral attributes) of mixed-signal systems and evaluate the feature range over dense time interpretation of AMS assertions. Unlike assertions, which have a Boolean evaluation, features evaluate to real-valued ranges, which provide a better insight of the robustness of the system.

In the first part of the thesis we have proposed methodologies for evaluating features of AMS designs and validating AMS assertions with local variables and have developed two tool-kits, Dynamic Feature Evaluation Tool (DyFET) and AMS-Assertion Checker. Both these tools are integrated to standard mixed-mode simulation engines through standard APIs.

In the latter part of the thesis, the proposed frameworks are used for the assertion based analysis of two types of AMS systems, namely, AMS circuits, and power system networks. The research presented here is as follows:

- *AMS Circuits:* We propose the notions of feature based equivalence and feature-driven coverage analysis for the verification of AMS circuits.

- *Power System Network:* We study the use of assertions and features for analyzing some of the decision problems of a power system network, namely, diagnosis of faults and prognosis of grid vulnerability.

Keywords: Assertions, Features, Mixed-Signal Systems, Verification of AMS Circuits, Analysis of Smart Electrical Grids.