Interactive Compact Device Modeling Using Qucs Equation Defined Devices

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The Qucs EDD model is an innovative nonlinear component. It allows easy construction of compact device models and circuit macromodels via the Qucs GUI, allowing fast prototyping prior to translation into Verilog-A and model implementation using ADMS. This is a major step forward for Qucs. It should be of interest to anyone designing and testing compact device and integrated circuit simulation models.

References:

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Introduction

The latest Qucs release reads a turning point in the development of the Qucs device and circuit modeling facility. Release 0.0.11 introduced component values defined by equations, and for the first time allowed subcircuits with parameters. Release 0.0.12 introduced these features to add device modeling constructs using symbolic equations that are similar to model code written in the Verilog-A language. In designing the latest Qucs modeling features the Qucs team has attempted to address the need to provide the package with an interactive and easy to use modeling system that allows fast compact device and circuit macromodel construction.

The Qucs equation defined device (EDD)

• Qucs EDD is a multiparameter nonlinear component with branch currents that can be a function of the branch voltages, and stored charge that can be a function of both branch voltages and currents. EDD is similar, but more advanced, to the B type controlled source implemented in SPICE 3f5.
• EDD is capable of modeling the same models as the SPICE B device plus an extensive range of more complex compact device models.
• EDD is an advanced component, allowing users to construct their own models from a set of equations derived from physical device properties.
• EDD models can be combined with conventional circuit components and Qucs equation blocks to build compact device subcircuits.

The Qucs EDD structure

An EDD model is a nonlinear component with up to eight branches. Each branch has current I, voltage V, charge Q, and stored charge. The branch current can be increased if required. Branches with I<0 and V<0 are connected to external inputs, and act high impedance voltage probes. Fig. 1 shows an EDD model for a transistor diode. The diode V-I characteristics are set by a substantial set of parameters defined in the SPICE diode model parameters [1]. Conditional branch current and charge equations can be selected by if-then-else statements with a C like ternary operator (? : ) syntax. Nested if statements are allowed. EDD equations may include branch current and charge equations can be selected by if-then-else statements with a C like ternary operator (? : ) syntax. Nested if statements are allowed. EDD equations may include branch current and charge equations.

Modeling diode temperature effects

Diode capacitance effects

The next stage in the development of the EDD diode model illustrated in Fig. 6 is to add capacitance effects. See Table 1 for device data and Table 2 for device parameters. Table 3 shows the forward bias diode current in I/V vs. T. Table 4 shows the EED model capacitance and Table 5 shows the EED model capacitance. Diode capacitance effects are sometimes present in compact device and circuit macromodels. The model and circuit capacitance in Fig. 7b shows that the EED diode model handles each situation. This example demonstrates the use of a symbol with an EED model to form a nonlinear transformation of the form implemented in SPICE 2g6.

Compact device subcircuits with package parasitic components

Non-linear passive components

Summary: The Qucs EDD model is an innovative nonlinear component. It allows easy construction of compact device models and circuit macromodels via the Qucs GUI, allowing fast prototyping prior to translation into Verilog-A and model implementation using ADMS. This is a major step forward for Qucs. It should be of interest to anyone designing and testing compact device and integrated circuit simulation models.

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