Fuse Modeling and Characterization For QEX Publication

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Abstract-This paper presents a behavioral model for the electric fuse which can be realized for conserved computer simulation with applications such as LTSpice. The model simplifies simulation by translating the traditional time integral square of instantaneous current (i2t) into the thermal domain (Rθi2R). This approach is unique in that the primary modeling consideration is given to the device as a low-current self-heating resistor given a unity ζ current order coefficient. At unity ζ values, the device is able to dissipate thermal energy as fast as it comes in. At a crossover current, a ζ order coefficient increases from unity for a fusing effect where the device is no longer able to dissipate thermal energy as fast as it comes in. The net result is a translation of the published i^2t profile into the thermal domain. The model has a thermal network to the ambient with a user-defined simulation precision of the published characterization i^2t profile together with a transient voltage response in the low current region that accurately duplicates published behavior. Owing to its low numerical overhead, the model is highly productive within LTSpice and various qualified analog conserved circuit solvers for whole systems simulations.

SUMMARY OF PRESENTATION:

A behavioral simulation model and characterization method is presented for the electric fuse. The concept behind the model is easily exportable to virtually any conserved analog simulation tool (i.e. VHDL-AMS,[1] MODELICA,[2] MAST,[3] LTSpice[4]). The purpose of the model is to allow low-overhead simulation within a much larger system simulation with any number of other electro-mechanical components. It is therefore necessary that the model be simple, robust, reflecting published performance. The model's characterization is highly algorithmic, leaving little to engineering judgement. It is premised upon a concept of translating the traditional time integral square of instantaneous current (i^2t) into the thermal domain.

THE FIRST ORDER FUSE MODEL—A SELF-HEATING RESISTOR:

The primary element of a fuse model (valid only for a first order) may be represented by the circuit illustrated in Figure 1. An electric current is driven through a resistor, r. The electrical domain energy of the resistor (i^2r) is transformed to thermal energy represented as $(R_{th}i^2R)_q$. A dotted line connects the thermal and electrical grounds which, for simulation purposes, are the same. T_o represents a temperature drop from the thermal resistance referred to a de facto ambient temperature

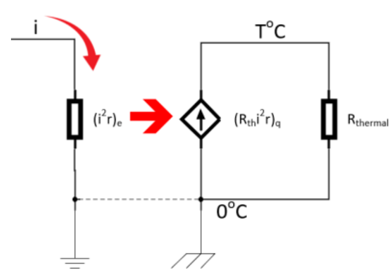

Figure 1 Self-heating resistor model where electrical energy is transferred into the thermal domain.

[1] IEEE Transaction Volume 46 Issue 10, VHDL-AMS-a hardware description language for analog and mixed-signal applications.
[2] Modelica Association, board@modelica.org, Sweden.
[3] Synopsys Modeling Languages, MAST and VHDL-AMS IEEE Standard 1076-2008 (VHDL)
[4] Analog Devices, Wilmington, MA, www.analog.com