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Modeling Voltage-Controlled and Temperature-Dependent Resistors

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OVERVIEW

Analog Behavioral Modeling (ABM) can be used to model a nonlinear resistor through use of Ohms law and tables and expressions which describe resistance. Here are some examples.
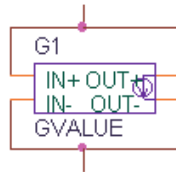
VOLTAGE-CONTROLLED RESISTOR

If a Resistance vs. Voltage curve is available, a look-up table can be used in the ABM expression. This table contains (Voltage, Resistance) pairs picked from points on the curve. The voltage input is nonlinearly mapped from the voltage values in the table to the resistance values. Linear interpolation is used between table values.

Let's say that points picked from a Resistance vs. Voltage curve are:

Voltage	Resistance
0.5	25
1.0	50
2.0	100

The ABM expression for this is shown in Figure 1.

V(%IN+, %IN-)/TABLE(V(%IN+, %IN-), 0.5,25, 1.0,50, 2.0,100)

Figure 1: Voltage controlled resistor using look-up table

TEMPERATURE-DEPENDENT RESISTOR

A temperature-dependent resistor (or thermistor) can be modeled with a look-up table, or an expression can be used to describe how the resistance varies with temperature. The denominator in the expression in Figure 2 is used to describe common thermistors. The TEMP variable in the expression is the simulation temperature, in Celsius. This is then converted to Kelvin by adding 273.15. This step is necessary to avoid a divide by zero problem in the denominator, when T=0 C.

NOTE: TEMP can only be used in ABM expressions (E, G devices).

Figure 3 shows the results of a DC sweep of temperature from -40 to 60 C. The y-axis shows the resistance or V (I1:-)/1A.
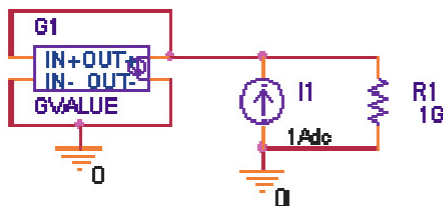
PARAMETERS:
rho = 10k
beta = 3435
temp0 = 298

V(%IN+, %IN-)/(rho*exp(-(beta*(TEMP+273.15-temp0))/((TEMP+273.15)*temp0)))

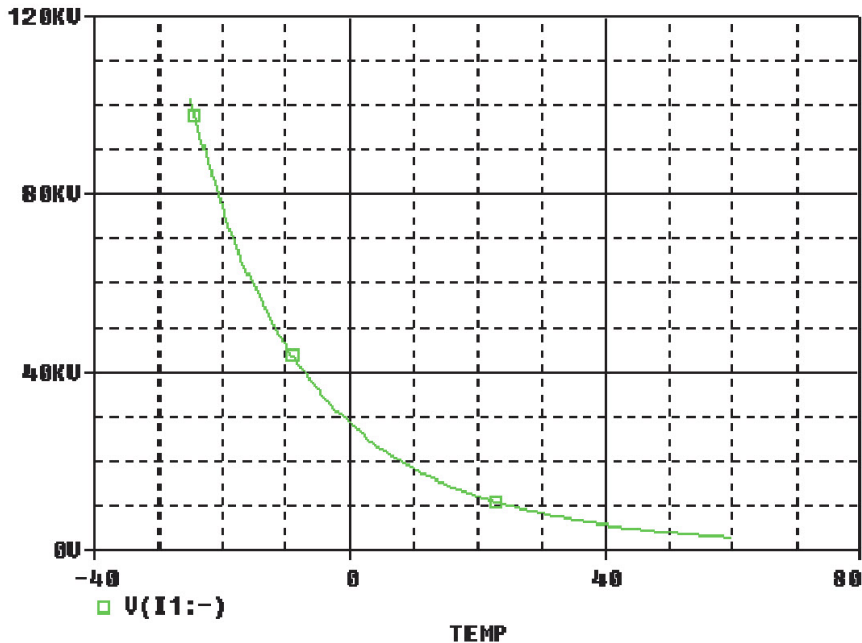*Figure 2: Temperature controlled resistor*

Figure 3: PSpice® plot of Resistance vs. Temperature (current=1A)

VARIABLE Q RLC NETWORK

In most circuits the value of a resistor is fixed during a simulation. While the value can be made to change for a set of simulations by using a Parametric Sweep to move through a fixed sequence of values, a voltage-controlled resistor can be made to change dynamically during a simulation. This is illustrated by the circuit shown in Figure 5, which employs a voltage-controlled resistor.
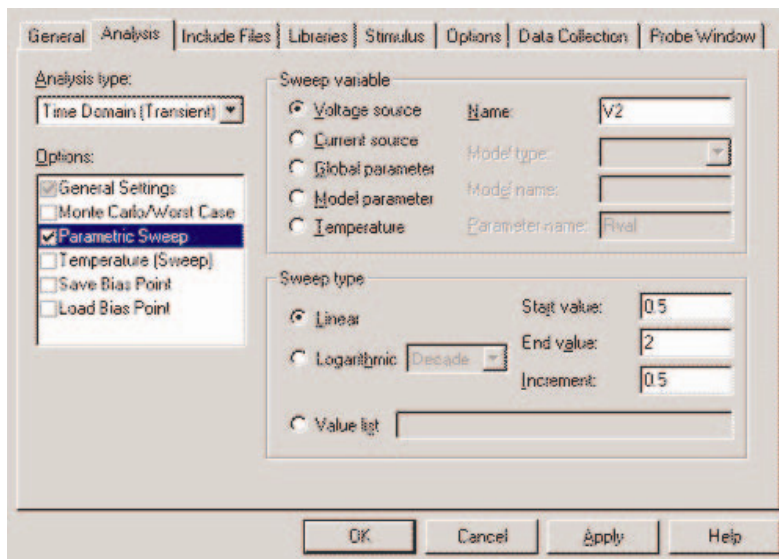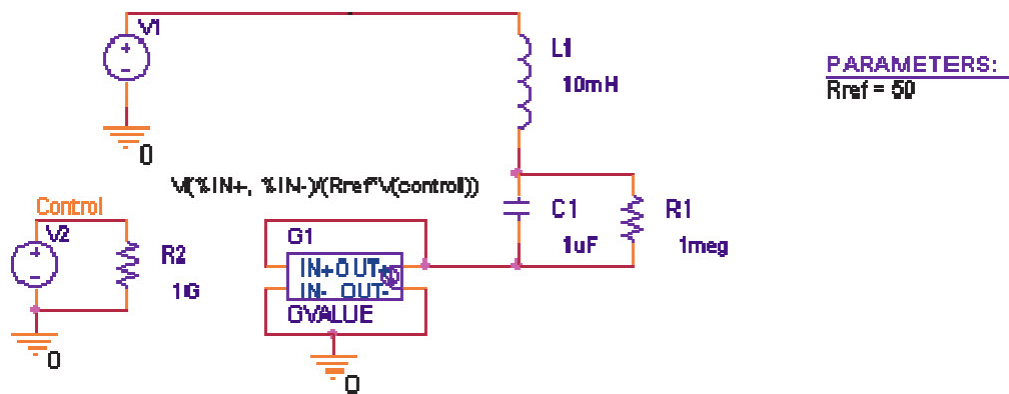

Figure 4: Parameter sweep of control voltage

This circuit employs an external reference component that is sensed. The output impedance equals the value of the control voltage times the reference. Here, we will use Rref, a 50 ohm resistor as our reference. As a result, the output impedance is seen by the circuit as a floating resistor equal to the value of V (Control) times the resistance value of Rref. In our circuit, the control voltage value is stepped from 0.5 volt to 2 volts in 0.5 volt steps; therefore, the resistance between nodes 3 and 0 varies from 25 ohms to 100 ohms in 25 ohm-steps.

APPLICATION NOTE

V1

L1
10mH

PARAMETERS:
Rref = 50

0

V(%IN+, %IN-)/(Rref*V(control))

Control

V2

R2
1G

G1
IN+ OUT+
IN- OUT-
GVALUE

C1
1uF

R1
1meg

0

0

0

TRAN = PULSE(0V, 1V, 0.5ms, 1us, 1us, 0.5ms, 4ms)

Figure 5: Variable Q RLC circuit

A transient analysis of this circuit using a 0.5 ms wide pulse will show how the ringing differs as the Q is varied.

Using Probe, we can observe how the ringing varies as the resistance changes. Figure 6 shows the input pulse and the voltage across the capacitor C1. Comparing the four output waveforms, we can see the most pronounced ringing occurs when the resistor has the lowest value and the Q is greatest. Any signal source can be used to drive the voltagecontrolled resistance. If we had used a sinusoidal control source instead of a staircase, the resistance would have varied dynamically during the simulation.
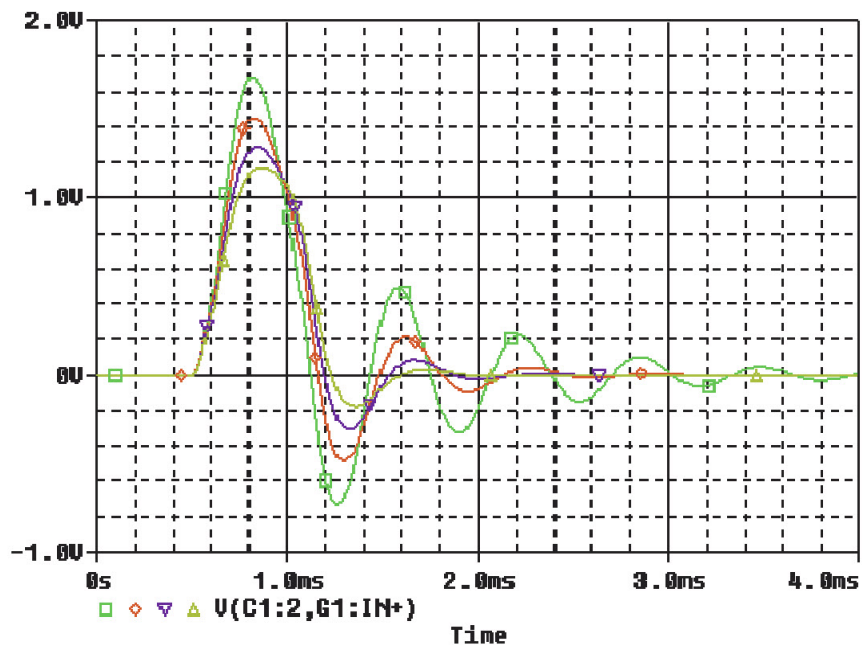

Figure 6: Output waveforms of variable Q RLC circuit

APPLICATION NOTE