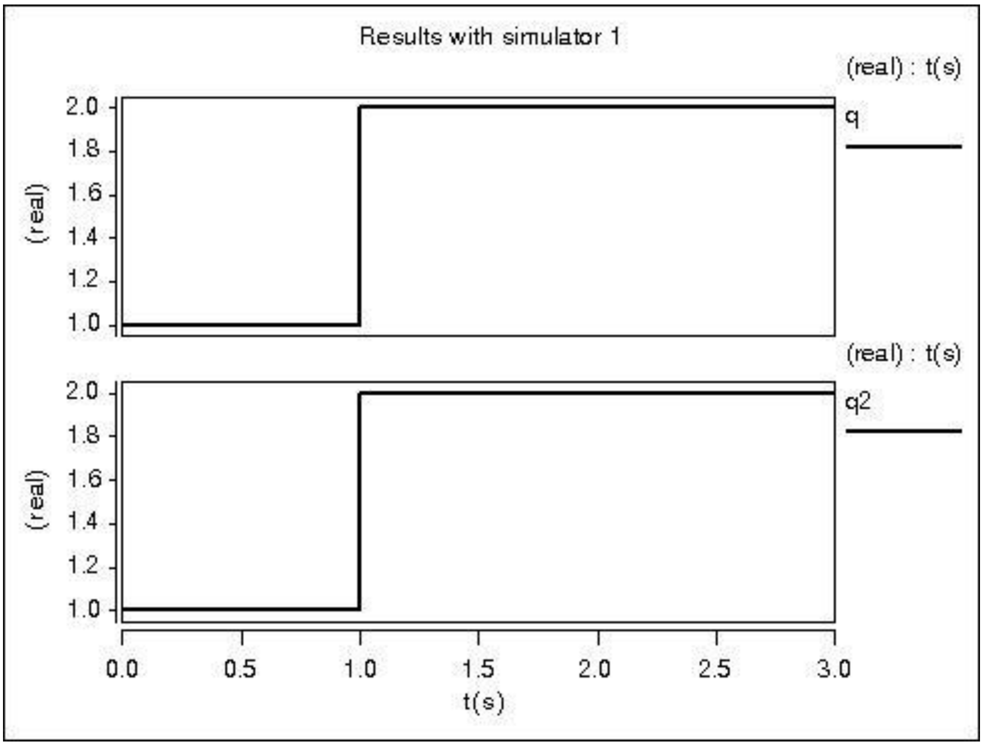
´SLEW discussion

Example with break

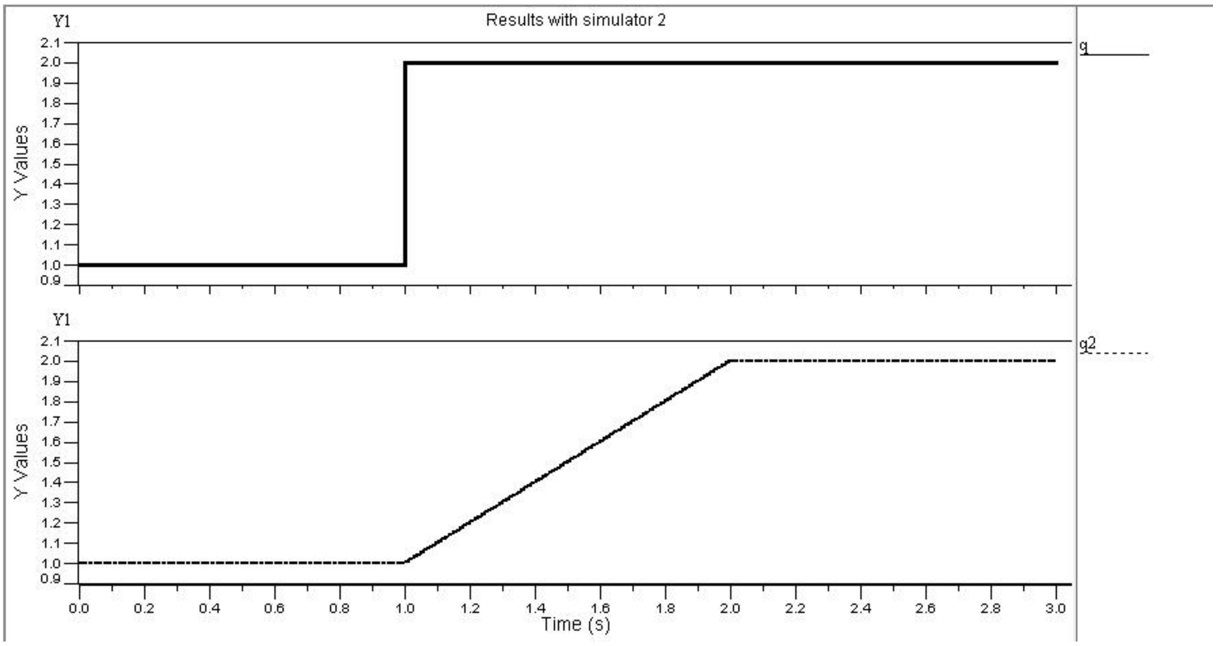
```
entity BENCH is end entity BENCH;

architecture A0 of BENCH is

   quantity Q, Q2 : REAL;
   signal   S     : BOOLEAN := TRUE;

begin

   S <= TRUE, FALSE after 1 sec;

   if S use
      Q == 1.0;
   else
      Q == 2.0;
   end use;

   break on S;

   Q2    == Q'SLEW(1.0, -1.0);

end architecture A0;
```

Different results with different tools

Simulator 1



Simulator 2

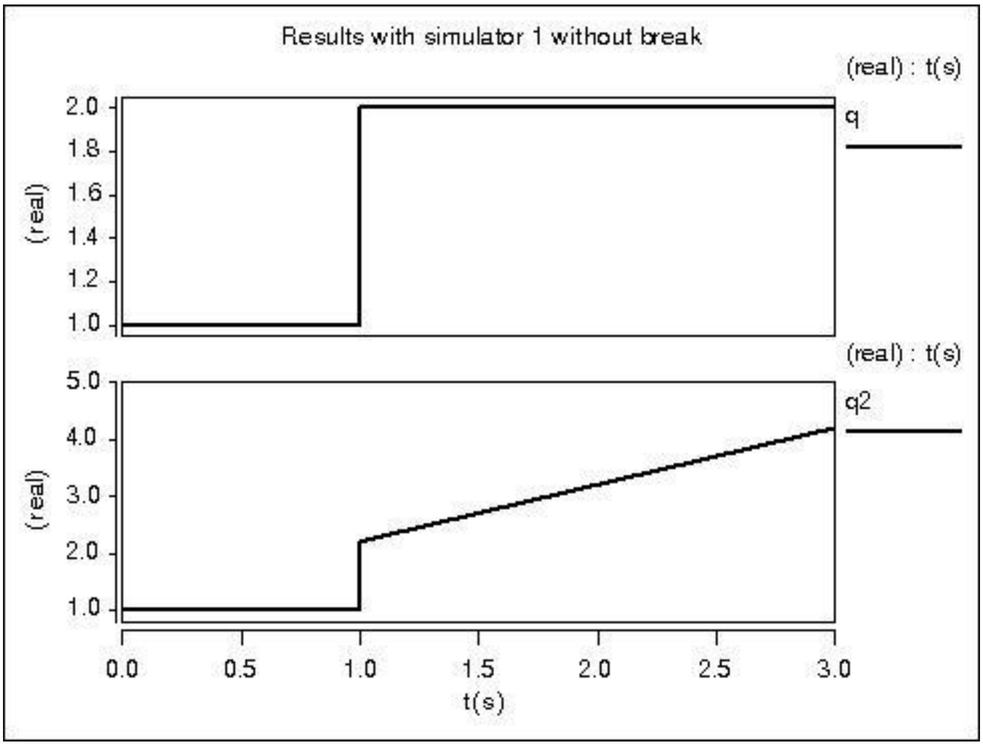

Results with simulator 2
Y1
Y Values
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
q
Y1
Y Values
q2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Time (s)

Example without break

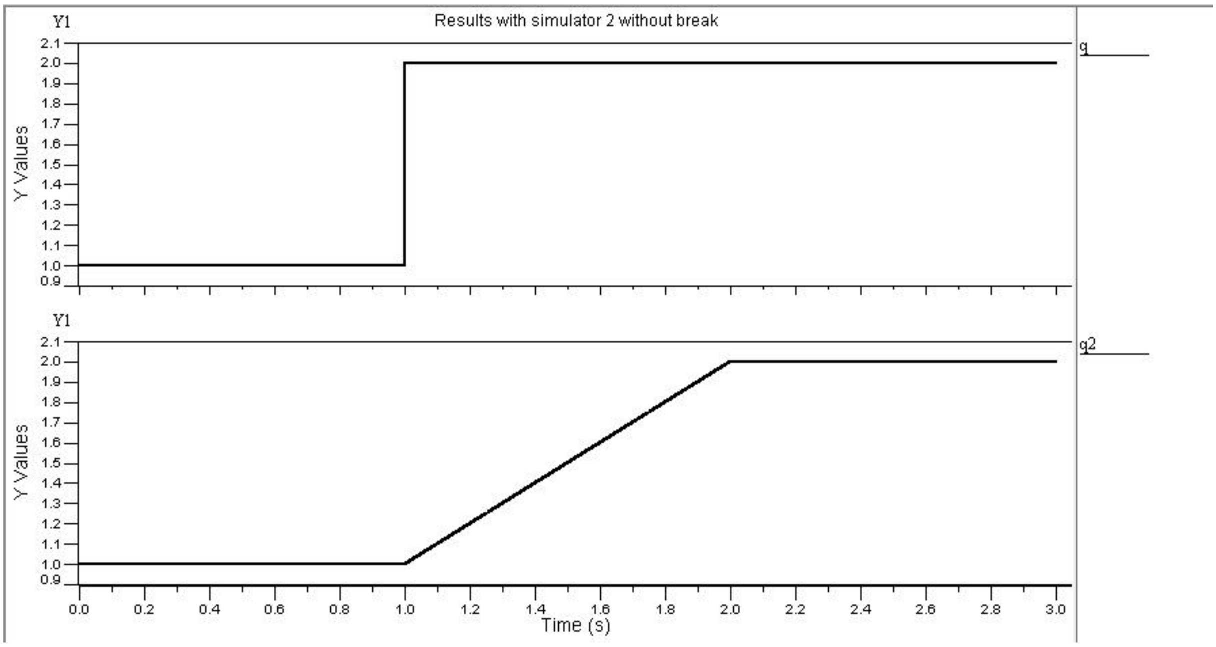
```
entity BENCH is end entity BENCH;

architecture A0 of BENCH is

   quantity Q, Q2 : REAL;
   signal   S     : BOOLEAN := TRUE;

begin

   S <= TRUE, FALSE after 1 sec;

   if S use
      Q == 1.0;
   else
      Q == 2.0;
   end use;

   Q2    == Q'SLEW(1.0, -1.0);

end architecture A0;
```

Different results with different tools

Simulator 1



Simulator 2



Results with simulator 2 without break
Y1
Y Values
q
q2
Time (s)

LRM - Determination of Q'DOT

Behavioural languages - Part 6: VHDL Analog and Mixed-Signal Extensions,
IEEE Std 61691-6 , Dec. 14 2009. DOI 10.1109/IEEESTD.2009.5465882

8.14 Break statement

The execution of a break statement notifies the analog solver that it shall determine the discontinuity augmentation set for the next analog solution point. It may also specify reset values for quantities. The effect is conditional if the statement includes a condition.

[..] NOTE—It is a consequence of these definitions that in the absence of a selector clause in a break element the corresponding break quantity shall be either the prefix Q of a quantity of the form Q'DOT that appears in the text of the model or a quantity of the form Q'INTEG.

12.6.5.1 Quiescent state augmentation set

The quiescent state augmentation set is the collection of characteristic expressions that, when combined with the structural set and an explicit set, allows the analog solver to determine the quiescent or "DC" values of the quantities of the model.

[…]Each scalar subelement of each quantity of the form Q'DOT is a characteristic expression of the quiescent state augmentation set.

12.6.5.3 Discontinuity augmentation set

[…] The difference between each scalar subelement of the prefix Q of each quantity of the form Q'DOT and the numeric value of that scalar subelement of Q when the discontinuity augmentation set is determined is a characteristic expression of the discontinuity augmentation set.

12.6.5.2 Time domain augmentation set

[…] The difference between each scalar subelement of each quantity of the form Q'DOT and the derivative with respect to time of the corresponding scalar subelement of its prefix Q is a characteristic expression of the time domain augmentation set.

[…] The derivative with respect to time and the integral over time have their conventional mathematical meaning.

Comments

Determination of Q‘DOT

A solution (of the analog part) must fulfill the characteristic equations that are given by

- the structural set of equations (given by Kirchhoff Current and Voltage Law for instance)
- the explicit set of equations (diven by the simulataneous statements)
- the augmentation set - especially
  - for quiescent domain analysis (DC)
  - at discontinuities
  - for time domain analysis (besides discontinuites)

The idea behind (to my opinion) is to describe the simulation problem by a DAE system

F(x, x‘, t) = 0

where the x(t) are elements of R^n and the derivatives of m<= n components of x are arguments of F. The range of the map F is the R^n.

Thus, during quiescent domain analysis we need m additional equations to deterime x(0) and x‘(0). These additional equations are given by the quiescent domain augmentation set that can be modofied by the break statement. An equivalent situation occurs at a discontinuity at time t0 that is announced by a break statement. Based on structural, explocit and discontinuity augmentation set x(t0) and x‘(t0) can determined. Thus, after a discontinuity the time domain analysis can be „restarted“ with the new initial value x(t0).

By the way. the values x(0) and x(t0) must be consistent inital values of the DAE system given by F. It is not obvious (to me) that this requirement can always be fulfilled with (default) augmentation sets. But this is beyond the ´SLEW discussion.

Thus, **if the discontinuity is announced** by a break statement the derivatives are not determined numerically based on the difference of two or more values. The may be differences between left and right hand-side values oft he derivatives as well as of the waveform values.

If **the discontinuity is not announced** by a break statement the derivatives are determined based on the time domain augmentation set. That means in general, they are determined based on the difference of values at two or more different time points.

Interpretation of the results of the examples

Example with break statement (discontinuity at time t0)

Simulator 1 seems to apply the discontinuity augmentation set. It might be that all derivatives that are not used by the map F are set to 0 in this case. It also might be that the derivative Q´DOT at t0+ is determined based on Q(t0+) and Q(t0 + h). Q´SLEW is determined based on the zero value oft he derivative.

Simulator 2 seems to handle this case in the same way as without breakstatement.

Example without break statement (discontinuity at time t0)

Both simulators do not apply the discontinuity augmentation set. Simultator 1 seems to use at t0 (step size h)

Q'SLEW at t0 = Q(t0-h) + h*f(Q'DOT(t0-h), MIN_SLOPE, MAX_SLOPE)

whereas simulator 2 seems to use

Q'SLEW at t0 = Q(t0-h) + h*f((Q(t0) – Q(t0-h))/h, MIN_SLOPE, MAX_SLOPE)

What does this mean for the standard?

If a break statement announces the discontinuity, the simulator 1 delivers to my opinion a result that is in accordance with the LRM. However, the result is not intuitive. It seems to me that it might be possible to avoid this situation by extending the discontinuity augmentation set. It should be assured that Q'SLEW is continuous if the SLOPES are finite.

It might be checked whether the definition of a value of Q'SLEW at time t0 could explicitely consider the history of Q.