

IBIS Model Simulation with R/L/C_dut

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Outline

- Introduction of IBIS R/L/C_dut subparameters
- IBIS algorithm enhancement for R/L/C_dut
- Accuracy test of complete IBIS model with R/L/C_dut
- Summary

Introduction of IBIS R/L/C_dut subparameters

IBIS 3.2:

V-T waveform subparameters

The R_dut, C_dut, and L_dut subparameters are analogous to the package parameters R_pkg, C_pkg, and L_pkg and are used if the waveform includes the effects of pin inductance/capacitance



Example:

```
[Rising Waveform]
R_fixture = 50
V_fixture = 0.0
| C_fixture = 50p
| L_fixture = 2n
| C_dut = 7p
| R_dut = 1m
| L_dut = 1n
| Time V(typ)
```

IBIS Algorithm Without R/L/C_dut



Two steps to get scaling coefficients of PU, PD (Ku,Kd)

- 1. Get Idie(t) by V-T waveforms, C_comp and R/L/C_fixture : apply i=C*dv(t)/dt and v=L*di(t)/dt
- 2. Use the well known 2EQ/2UK algorithm:

```
0 = Ku(t) * Iu(Vwfm1(t)) + Ipc(Vwfm1(t)) - Kd(t) * Id(Vwfm1(t)) - Igc(Vwfm1(t)) - Idie(Vwfm1(t)))0 = Ku(t) * Iu(Vwfm2(t)) + Ipc(Vwfm2(t)) - Kd(t) * Id(Vwfm2(t)) - Igc(Vwfm2(t)) - Idie(Vwfm2(t)))
```

For details , please refer:

"IBIS Algorithm Including Reactive Loads", Xuefeng Chen, Asian IBIS Summit (China), September 11, 2007.

IBIS algorithm enhancement for R/L/C_dut



The step 1 of Vdie(t) & Idie(t) calculation extends to:

- a) get I(L_fixture) by Vwaveform(t) and L/R/C/V_fixture.
- b) get I(C_dut) by Vwaveform(t) and C_dut.
- c) get I(L_dut) by above I(L_fixture) and I(C_dut).
- d) get Vdie(t) by I(L_dut), L_dut, R_dut and Vwaveform(t).
- e) get I(C_comp) by Vdie(t) and C_comp
- f) get Idie(t) by I(C_comp) and I(L_dut).



A Complete IBIS Model with R/L/C_dut





Accuracy Test of the Complete IBIS Model with R/L/C_dut

The output result by original IBIS algorithm (ignore R/L/C_dut) when the buffer is loaded with R/L/C/V_fixtures:



v(output_ibis): IBIS output v(output_hspice): HSPICE transistor level buffer output



Accuracy Test of the Complete IBIS Model with R/L/C_dut (Cont.)

The output result by enhanced IBIS algorithm (consider R/L/C_dut in V-T solving) when the buffer is loaded with R/L/C/V_fixtures:



v(output_ibis): IBIS output v(output_hspice): HSPICE transistor level buffer output

Accuracy Test of the Complete IBIS Model with R/L/C_dut (Cont.)

Ku, Kd comparison between original IBIS algorithm and enhanced IBIS algorithm:



Due to R/L/C_dut, the Ku, Kd results look more noisy. But it contributes for much better accuracy of output waveform!

Accuracy Test of the Complete IBIS Model with R/L/C_dut (Cont.)

The output result comparison between original and enhanced IBIS algorithms when the buffer is loaded with W element and IBIS terminators:



v(output_ibis): IBIS output v(output_hspice): HSPICE transistor level buffer output

Summary

- Enhanced IBIS algorithm is provided to support the R/L/C_dut subparameters in V-T tables.
- The algorithm can get perfect match to transistor level buffer under the loading conditions of V-T extraction, and shows obvious accuracy improvement when the buffer is loaded with W element and IBIS terminator.
- The Ku & Kd results of V-T solving is very sensitive to R/L/C_dut. So IBIS model extractors need be cautious to use such subparameters.
- In fact, based on the algorithm, R/L/C_dut provides a solution to describe a little more complicated "C_comp" circuit due to below common situations:
 - ✓ located between V-T extraction point and die pad
 - \checkmark involved in V-T solving to get Vdie(t) & Idie(t)
 - \checkmark the values are constant for different V-T tables.
 - \checkmark need to be added in circuit during buffer simulation

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