IBIS [Driver Schedule] modeling
Eckhard Lenski
SPI, Hildesheim, Germany
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IBIS driver schedule modeling

Summary

Driver schedule Design 1

Package influence

Driver schedule Design 2

Static check

Driver schedule Design 3
# General timing schedule

## [Driver Schedule]

<table>
<thead>
<tr>
<th>Model_name</th>
<th>Rise_on_dly</th>
<th>Rise_off_dly</th>
<th>Fall_on_dly</th>
<th>Fall_off_dly</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL_1</td>
<td>0.5ns</td>
<td>NA</td>
<td>0ns</td>
<td>NA</td>
</tr>
<tr>
<td>MODEL_2</td>
<td>1.0ns</td>
<td>NA</td>
<td>0ns</td>
<td>NA</td>
</tr>
<tr>
<td>MODEL_3</td>
<td>1.5ns</td>
<td>2.5ns</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model_name</th>
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<th>Rise_off_dly</th>
<th>Fall_on_dly</th>
<th>Fall_off_dly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>turn on pullup-structure</td>
<td>turn off pullup-structure</td>
<td>turn on pulldown-structure</td>
<td>turn off pulldown-structure</td>
</tr>
<tr>
<td></td>
<td>turn off pulldown-structure</td>
<td>turn on pulldown-structure</td>
<td>turn off pullup-structure</td>
<td>turn on pullup-structure</td>
</tr>
</tbody>
</table>

IBIS driver schedule modeling
scheduled models timing parameter

<table>
<thead>
<tr>
<th>Model_name</th>
<th>Rise_on_dly</th>
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<th>Fall_on_dly</th>
<th>Fall_off_dly</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL_1</td>
<td>1.0ns</td>
<td>2.5ns</td>
<td>0ns</td>
<td>NA</td>
</tr>
</tbody>
</table>

- rising edge (L->H):
  - turn on pullup-structure
  - turn off pullup-structure

- falling edge (H->L):
  - turn on pulldown-structure
  - turn off pulldown-structure
timing schedule vs datarate

[Driver Schedule]

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</tr>
</thead>
<tbody>
<tr>
<td>MODEL_1</td>
<td>0.0ns</td>
<td>NA</td>
<td>0ns</td>
<td>NA</td>
</tr>
<tr>
<td>MODEL_2</td>
<td>NA</td>
<td>0.4ns</td>
<td>NA</td>
<td>0.4ns</td>
</tr>
</tbody>
</table>

Model valid for one specific datarate

UI corresponds to Datarate

Eg. UI 400ps 2.5 Gbps

data pattern 11110100

time

V

1 1 1 1 0 1 0 0
Driver schedule

Design 1
Example 1 timing schedule
opsink plus opsink

[Driver Schedule]

<table>
<thead>
<tr>
<th>Model name</th>
<th>Rise on dly</th>
<th>Rise off dly</th>
<th>Fall on dly</th>
<th>Fall off dly</th>
</tr>
</thead>
<tbody>
<tr>
<td>3P3V_DRI-NSN-1+3_OUT</td>
<td>0.000ns</td>
<td>NA</td>
<td>0.000ns</td>
<td>NA</td>
</tr>
<tr>
<td>3P3V_DRI-NSN-1+4_OUT</td>
<td>NA</td>
<td>0.800ns</td>
<td>NA</td>
<td>0.800ns</td>
</tr>
</tbody>
</table>

Don't forget the clamp currents from the top level model, if any
Example 1 static curves

- **Main Model**
  - open-sink
  - MAIN-PD

- **Boost-1 Model**
  - open-sink
  - BOOST-PD

- **Toplevel Model**
  - open-sink
  - TOP-PD
Example 1 combined static curves

- static curves
  In one diagram
- combined curves
  - HIGH-Pre / HIGH / LOW / LOW-Pre

- MAIN-PD
- BOOST-PD
- PWRCLMP

- 50Ohm Vcc

- Low-Pre
  MAIN-PD + BOOST-PD + PWRCLMP

- Low
  MAIN-PD + PWRCLMP

- High
  BOOST-PD + PWRCLMP

- High-Pre
  PWRCLMP
Driver schedule
Design 2
Example 2  timing schedule
pu pd  plus opsink & opsource

[Driver Schedule]

<table>
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<th>Fall_on_dly</th>
<th>Fall_off_dly</th>
</tr>
</thead>
<tbody>
<tr>
<td>3P3V_DRI-NSN-CML-PREOFF_OUT</td>
<td>0.000ns</td>
<td>NA</td>
<td>0.000ns</td>
<td>NA</td>
</tr>
<tr>
<td>3P3V_DRI-NSN-CML-PRELO_OUT</td>
<td>NA</td>
<td>NA</td>
<td>0.000ns</td>
<td>2.000ns</td>
</tr>
<tr>
<td>3P3V_DRI-NSN-CML-PREHI_OUT</td>
<td>0.000ns</td>
<td>2.000ns</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. turn on PU  turn off PU  turn on PD  turn off PD
   turn off PD turn on PD  turn off PU turn on PU
2. turn on PU  turn off PU  turn on PD  turn off PD
   turn off PD turn on PD  turn off PU turn on PU
3. turn on PU  turn off PU  turn on PD  turn off PD
   turn off PD turn on PD  turn off PU turn on PU
Example 2 static curves

- Main Model with pullup and pulldown
  *(also Toplevel model)*

- Boost-1 Model open-sink

- Boost-2 Model open-source
Example 2 combined static curves

- static curves in one diagram
- combined curves
  - HIGH-Pre / HIGH / LOW / LOW-Pre

- combined curves

- 50Ohm Vcc

- MAIN-PD + BOOST1-PD
- MAIN-PD
- MAIN-PU
- BOOST1-PD
- BOOST2-PU
- HIGH-Pre
- MAIN-PU + BOOST2-PU
- MAIN-PU
- Low-Pre
- MAIN-PD + BOOST1-PD
- LOW / LOW-Pre
Driver schedule
Design 3
Example 3  timing schedule
pu pd  plus pu pd

[Driver Schedule]

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<th>Fall_off_dly</th>
</tr>
</thead>
<tbody>
<tr>
<td>3P3V_DRI-NSN+MAIN_OUT</td>
<td>0.000ns</td>
<td>NA</td>
<td>0.000ns</td>
<td>NA</td>
</tr>
<tr>
<td>3P3V_DRI-NSN+BOOST_OUT</td>
<td>0.400ns</td>
<td>NA</td>
<td>0.400ns</td>
<td>NA</td>
</tr>
</tbody>
</table>

1. turn on PU
2. turn off PD
3. turn off PD
4. turn on PU
5. turn off PU
6. turn on PD
7. turn off PD
8. turn on PD
9. turn off PU
10. turn off PD
11. turn on PU
12. turn off PD

Design 3

pu pd  plus pu pd
Example 3 static curves

- **Main Model**
  with pullup and pulldown
  
  (also Toplevel model)

- **Boost Model**
  with pullup and pulldown
  but with „inverse currents“
Example 3 combined static curves

- static curves in one diagram
- combined curves:
  - HIGH-Pre / HIGH / LOW / LOW-Pre

Main-PD

Boost-PD

Boost-PU

Main-PU

Voltage

Current

Low-Pre

Main-PD + Boost-PU

Low

Main-PD + Boost-PD

High

Main-PU + Boost-PU

High-Pre

Main-PU + Boost-PD

50Ohm Vcc
Static check & dynamic check

IBIS driver schedule modeling

Design 1

Driver schedule

Design 2

Driver schedule

Design 3

Static check

Package influence

Summary
compare dyn. levels – stat. levels

output currents

50Ohm 3p3v

curves U-I : static, blue

curves U-t : dynamic, yellow

Static check

High-Pre
High
Low
Low-Pre

2,5 2,7 3,1 3,3

Vout

0 2 4 6 8

Iout

LowPre
Low
High
HighPre
Each scheduled model will/can be checked as a single model with ibischk5.
compare golden waveform vs. stat. levels

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<td>0.0ns</td>
<td>NA</td>
</tr>
<tr>
<td>MODEL_2</td>
<td>0.0ns</td>
<td>0.8ns</td>
</tr>
</tbody>
</table>

outputcurrents

- LowPre
- Low
- High
- HighPre

50Ohm 3p3v

Prinzip Pre-/De-emphasis

driver
Checks for driver schedule models

Scheduled models:

• Check each model by itself for static vs. dynamic consistency (works with ibischk5)

Driver schedule:

• Create combined static curves corresponding timing schedule switching behavior
• Crossover with loadline should give corresponding voltage levels
• Compare with golden waveforms or by using the model in a simulator
• User has to take care that the „frequency“ corresponds to UI
simulation max pkg at pin vs measurement

Diff driver

Diff receiver

200ps

200ps
Simulation min pkg at pin vs measurement

Diff driver

Diff receiver

OSCILLOSCOPE
Design file: TEST 18-V 5.FFS   Designer: Lenski Eckhard
Hyperlynx V: 8.0
Comment: 5

Date: Friday Jan. 22, 2010   Time: 15:49:51

Voltage -mV-

V [ U4 . H2 (at pin) ]
V [ U3 . L4 (at pin) / U3 . L3 (at pin) ]
V [ U3 . L4 (at pin) ]
V [ U3 . L3 (at pin) ]

Time (ps)

0.00 400.0 800.0

drive 200ps

400mv

-300.0 -200.0 -100.0 0.00 100.0 200.0

200ps

-300.0 -200.0 -100.0 0.00 100.0 200.0 300.0 400.0

+300.0 +200.0 +100.0 0.00 100.0 200.0 300.0 400.0

-400.0 -300.0 -200.0 -100.0 0.00 100.0 200.0 300.0 400.0

400mv
Comparison with min and max pkg at pin

Min pkg
Cpkg 0.8pF
Lpkg 2.26nH

Max pkg
Cpkg 1.3pF
Lpkg 3.69nH

Diff driver
Diff receiver

400mv
200ps
Summary

• Driver schedule timing can be used to determine the datarate/frequency of the model

• There are many ways to create pre-emphasis behavior

• Static levels can be checked manually

• Golden waveform should exist

• The quality of the package model is extremely important

• How to use an s-param-file to include as package model?
Thank You

• Questions?