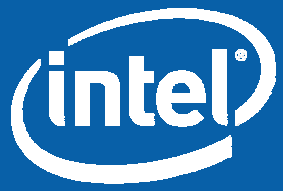


New Table-based Keywords in IBIS 5.0

A Cookbook-style Guide

Michael Mirmak
Intel Corporation
Chair, IBIS Open Forum
michael.mirmak@intel.com

马梦宽
英特尔公司
IBIS 委员会主席

IBIS Summit
Shanghai, China
November 11, 2008

亚洲 IBIS 技术研讨会
中国上海
2008 年 11 月 11 日

Legal Disclaimers

THIS DOCUMENT AND RELATED MATERIALS AND INFORMATION ARE PROVIDED "AS IS" WITH NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS, OR ANY WARRANTY OTHERWISE ARISING OUT OF ANY PROPOSAL, SPECIFICATION, OR SAMPLE. INTEL ASSUMES NO RESPONSIBILITY FOR ANY ERRORS CONTAINED IN THIS DOCUMENT AND HAS NO LIABILITIES OR OBLIGATIONS FOR ANY DAMAGES ARISING FROM OR IN CONNECTION WITH THE USE OF THIS DOCUMENT.

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.

Intel may make changes to specifications, product descriptions, dates and plans at any time, without notice.

*Other names and brands may be claimed as the property of others

IBIS Development

ANSI standard

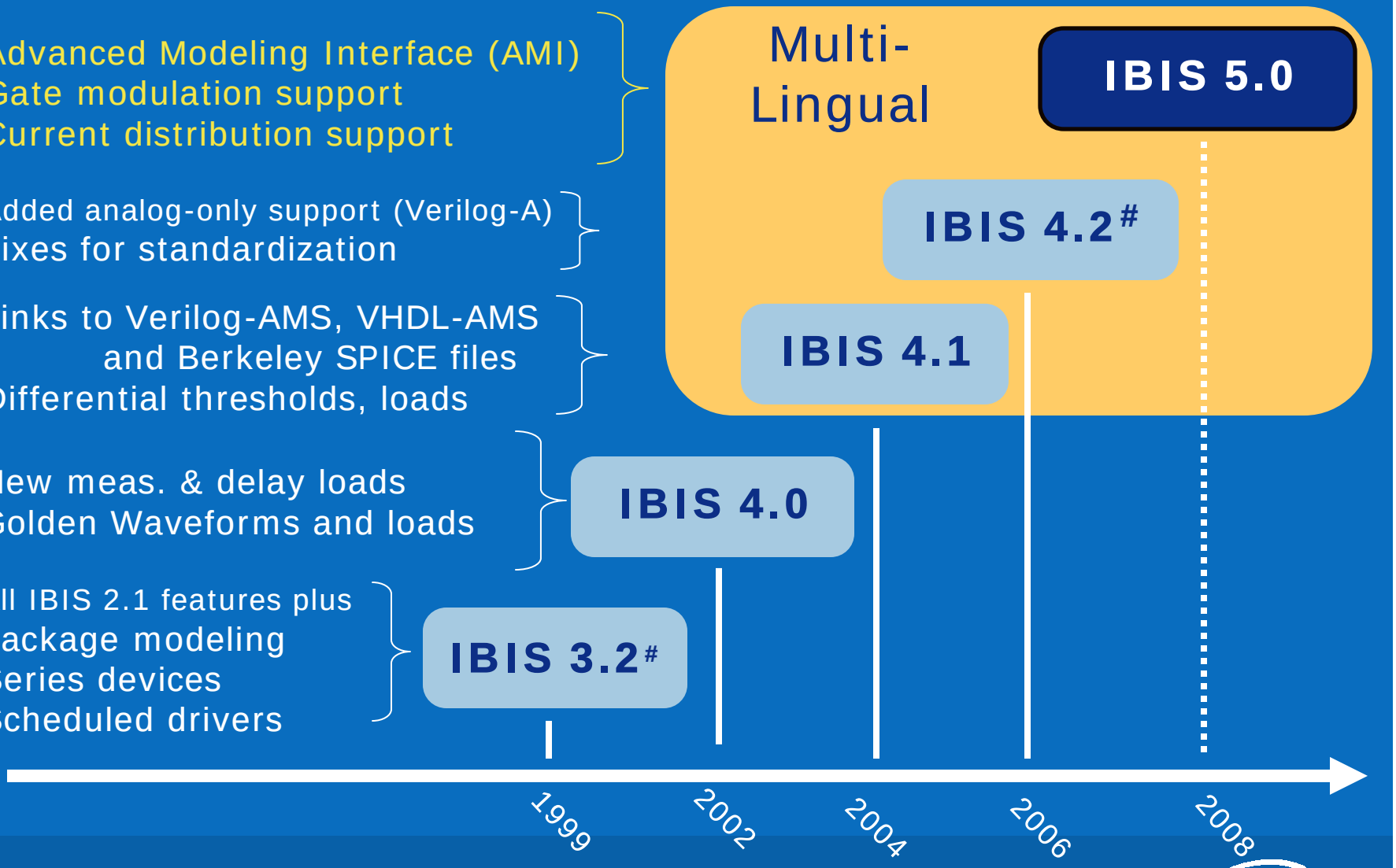
- Advanced Modeling Interface (AMI)
- Gate modulation support
- Current distribution support

- Added analog-only support (Verilog-A)
- Fixes for standardization

- Links to Verilog-AMS, VHDL-AMS and Berkeley SPICE files
- Differential thresholds, loads

- New meas. & delay loads
- Golden Waveforms and loads

- All IBIS 2.1 features plus
- Package modeling
- Series devices
- Scheduled drivers



Two New IBIS 5.0 Table-Based Keywords

- [ISSO_PD], [ISSO_PU]
  - *Originally called BIRD97/98*
  - *Characterizes buffer current modulation due to supply variation*
    - For example, SSO, “droop” or “bounce” events
    - Tools today scale the [Pulldown]… I-V tables, which is inappropriate
  - *Each one a table of current vs. voltage (I-V) data, per corner*

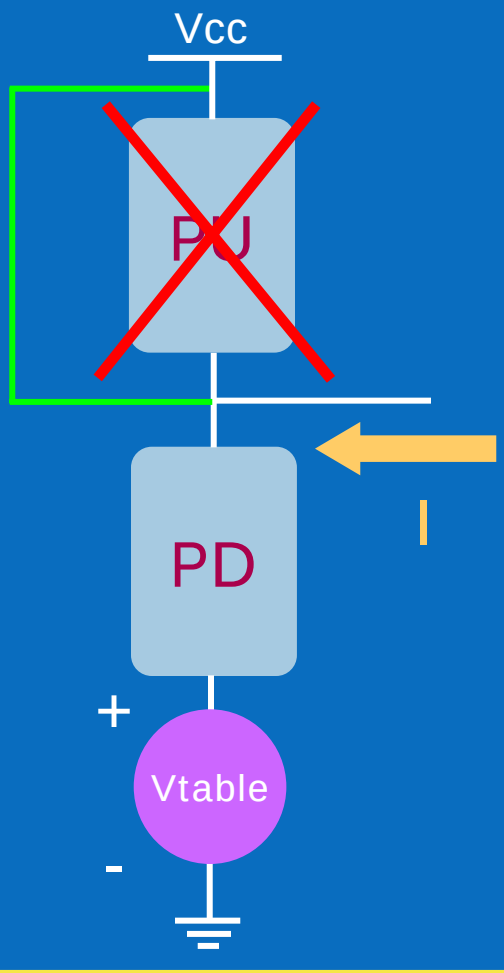
- [Composite Current]
  - *Originally called BIRD95*
  - *Characterizes currents from the supply rail through the buffer, as the buffer switches into a known load*
  - *A table of current vs. time (I-t) data, per corner*
  - *Resolves ambiguous rail current distribution from known pad current*
    - For example, can capture crowbar and/or pre-driver currents
    - Tools today “guess” at buffer current distributions

ISSO_PD

- *How is it extracted?*

Short-circuit effectively removes the pullup section

Pulldown section is “on” (buffer at logical 0)



Measure the current as voltage is swept from –Vcc to Vcc

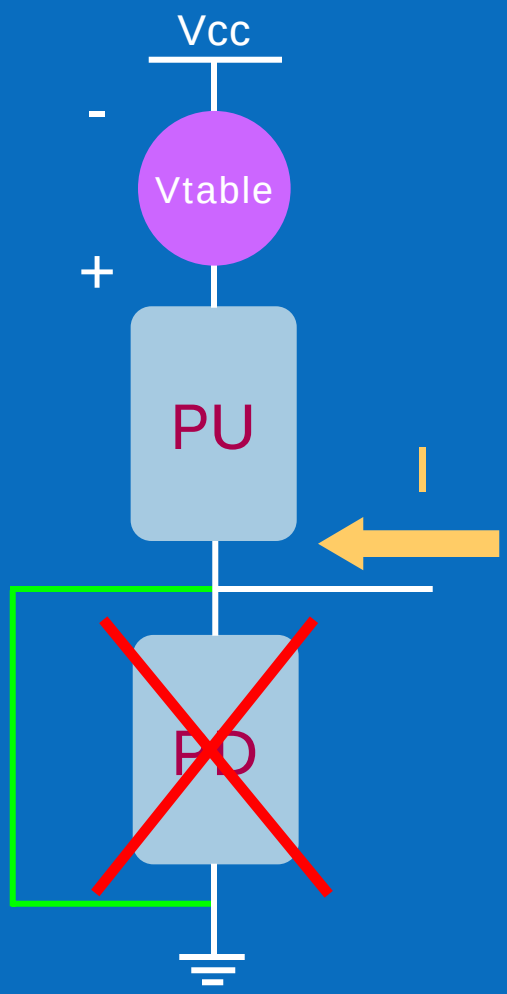
<u>Results</u>

An I-V table that characterizes pulldown strength as its reference voltage varies…

Similar to but different than [Pulldown], which characterizes output strength with *fixed* reference

ISSO_PU

- *How is it extracted?*



Pullup section is “on” (buffer at logical 1)

Short-circuit effectively removes the pulldown section

Measure the current as voltage is swept from –Vcc to Vcc (relative to Vcc!)

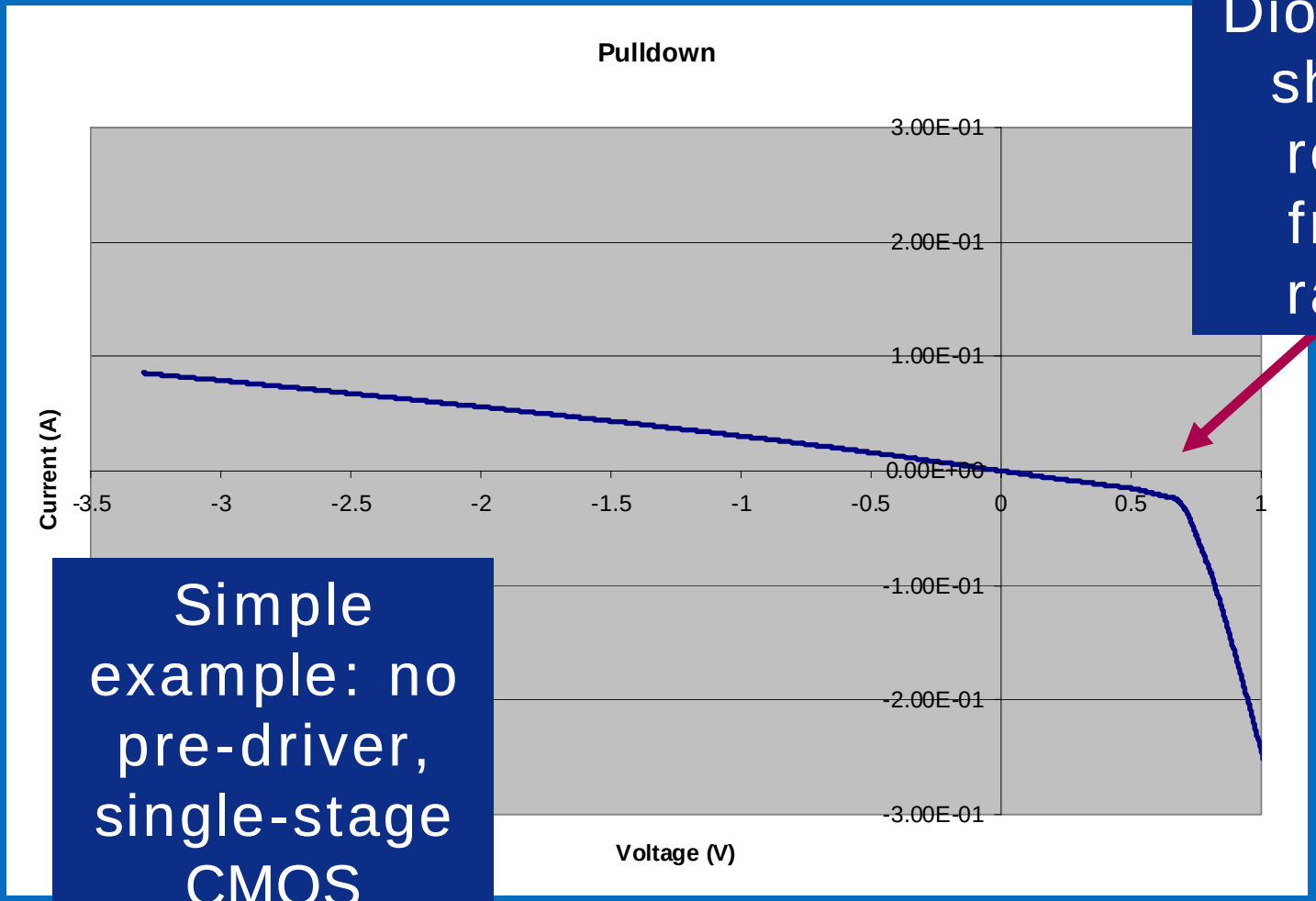
Results

An I-V table that characterizes pullup strength as its reference voltage varies…

Similar to but different than [Pullup], which characterizes output strength with *fixed* reference

ISSO_PD

- *What does the resulting waveforms look like?*



Diode effects should be removed from the raw data

Simple example: no pre-driver, single-stage CMOS

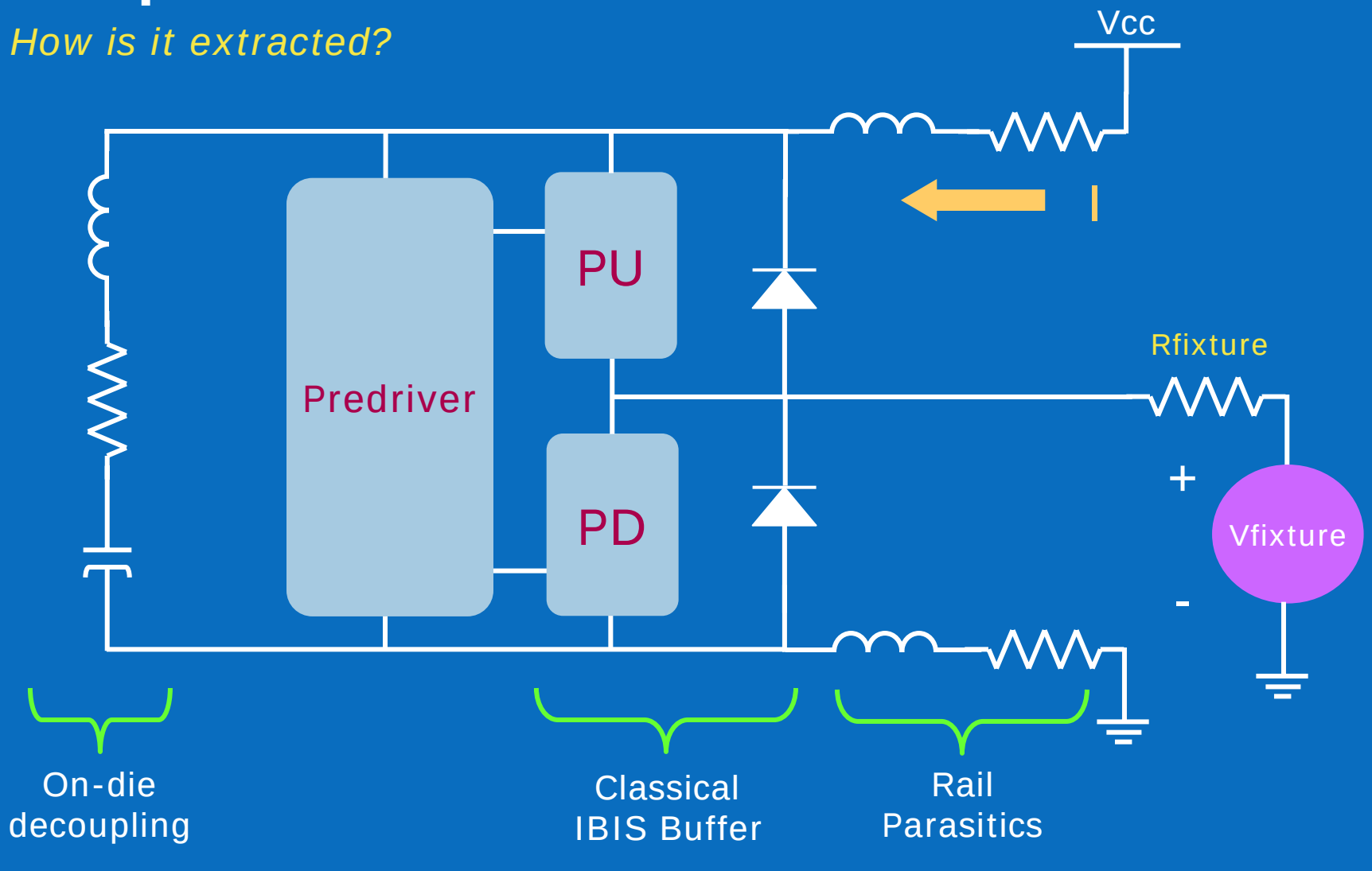
ISSO_PD, ISSO_PU - Recommendations

- Ensure that extraction polarities are correct
  - *Similar to sweep sources for [Pullup], [Pulldown]*
- Watch out for clamp currents
  - *Clamp currents should be excluded from ISSO tables*
  - *This includes on-die termination effects!*
- Watch out for reference voltages
  - *[Pullup Reference], [Pulldown Reference], etc. still apply*
- Beware of what isn't included
  - *ISSO keywords describe the final driver stage, not the pre-driver*
  - *The keywords describe static, not dynamic, current modulation*

Very similar to traditional I-V tables

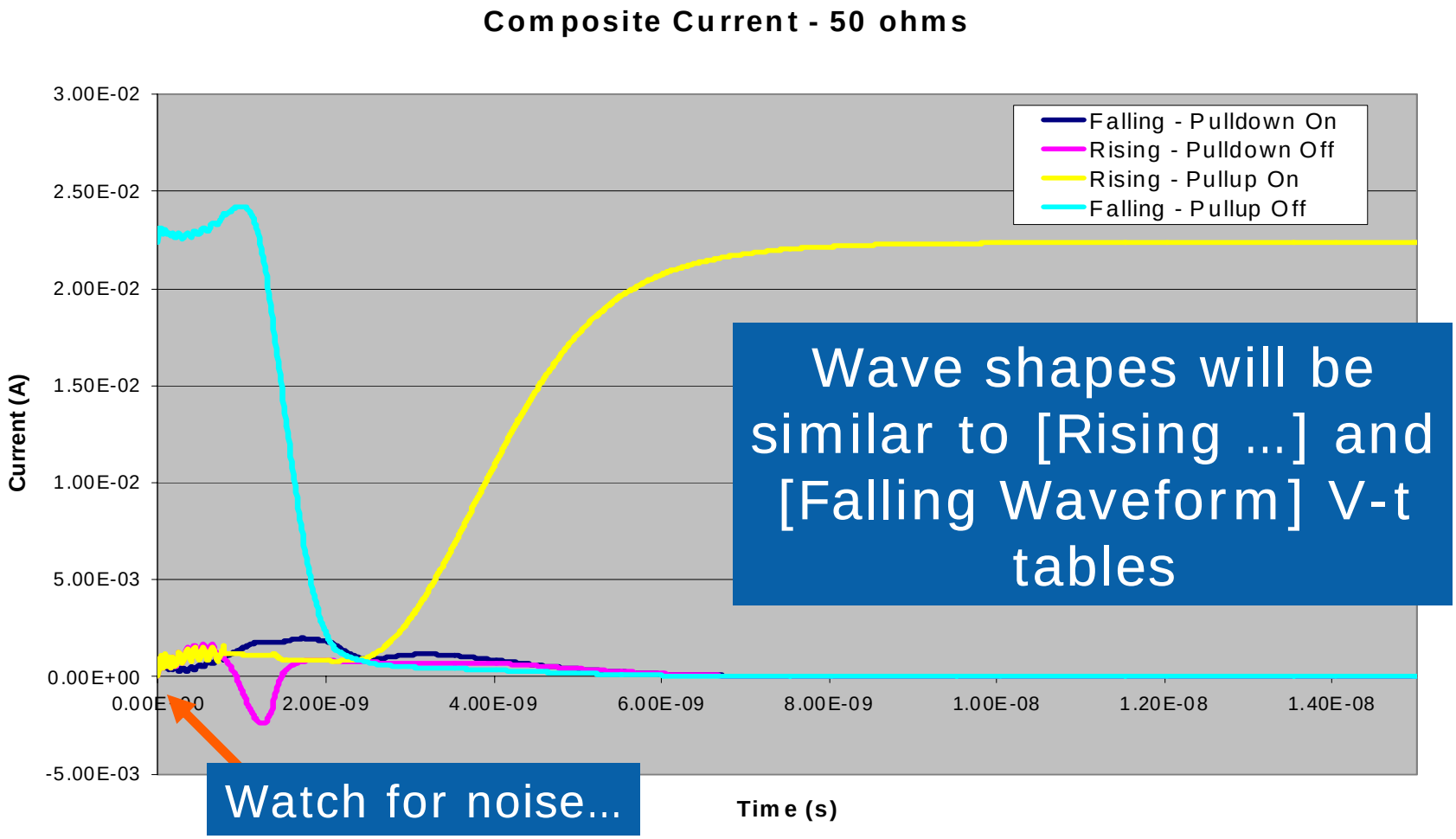
Composite Current

- *How is it extracted?*



Composite Current

- *What does the resulting waveform look like?*



Composite Current - Recommendations

- Supply sufficient data, ideally including…
  - *Tables using the same load as [Rising…] and [Falling Waveform]*
  - *Tables for no-load conditions (extremely high resistances)*
- Ensure the data is time-correlated to existing V-t tables
  - *Must start and end in states and with delays matching associated [Rising Waveform] and [Falling Waveform] tables*
- Make the power delivery structure is complete and includes…
  - *Buffer rail inductances and resistances*
  - *Pre-driver structures (if/when connected to the driver rails)*
  - *On-die decoupling structures, at buffer-level scale*
- Follow the same rules as for V-t tables
  - *Provide sufficient time-points for smooth transitions*
  - *Use resistive-only loads*

Very similar to traditional V-t tables
but using currents

Additional Notes

- Support
  - *IBISCHK5 parser should be available in the first half of 2009*
  - *No tools today support these keywords, or automatically extracting data for them*
- Today's Options
  - *SPICE templates can be created to extract the data manually*
  - *Composite Current data can be used with existing models in a SPICE implementation (see References)*
  - *The IBIS 5.0 specification contains guidance on [ISSO_PD], [ISSO_PU] adjustments to how I-V and V-t data interact*

Summary

- [ISSO_PD], [ISSO_PU]
  - *Characterize buffer supply voltage modulation*
  - *Resembles traditional I-V tables like [Pulldown]*
  - *Can capture gate variation, bounce and droop effects*

- [Composite Current]
  - *Characterizes buffer current distribution*
  - *Resembles traditional V-t tables like [Rising Waveform]*
  - *Can reveal and include crowbar current effects*

Start collecting data now, and encourage your model and EDA tool providers to support these keywords!

References

- Official IBIS Website, including tools, articles, specifications
  - http://www.eigroup.org/ibis/
- IBIS Specification 5.0
  - http://www.eda.org/ibis/ver5.0/
- IBIS Summit presentations
  - http://www.eda-stds.org/ibis/summits/index-bydate.htm
  - Excellent presentations in 2005 and 2006 cover BIRD 95 and 97/98
- Test Code and Development Documents
  - http://www.vhdl.org/pub/ibis/futures/
  - http://www.eda.org/ibis/docs/
- The IBIS 4.0 Cookbook – recommended for model creation!
  - http://www.eda-stds.org/ibis/cookbook/
- Join the IBIS and IBIS-Users e-mail reflectors!