Modeling the On-die De-cap of IBIS 5.0 PDN-aware Buffers

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Outline

- Introduction to IBIS 5.0 PDN modeling
- On-die de-coupling circuit
- A test case and workaround
- An issue?
- Conclusions
[Composite Current]

- Describes the shape of the rising and falling edge current waveforms from the power reference terminal of the buffer*.
- Adds pre-driver current I-t data.

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* Text and image from IBIS 5.0 Specification
Introduction to IBIS 5.0 PDN Modeling

[ISSO PU] & [ISSO PD]

- Data tables define the effective current of the pullup/pulldown structures of a
  buffer as a function of the voltage on the pullup/pulldown reference nodes*.
- Adds modeling of the gate modulation effect on driver current ($I_{DS}$ vs. $V_{GS}$).

* Text and image from IBIS 5.0 Specification
Introduction to IBIS 5.0 PDN Modeling

- IBIS 5.0 PDN modeling features are useful for SSN sensitive system designs
  - Parallel interfaces, Low power systems
  - Standard compliance models are interoperable and IP protected
- IBISCHK5 is up-to-date
  - Version 5.0.7 fixes BUG129
- At least 4 EDA simulators have implemented IBIS 5.0 PDN features
  - And more coming …
On-Die De-Coupling Circuit

- De-cap may be on the order of 500pF per buffer

* Image from IBIS 5.0 Specification
Test Case  IBIS Model

Extracted IBIS 5.0 Model – no on-die de-cap model
Test Case – IBIS vs. SPICE

Validation with perfect power supply

Good Match!
Test Case – IBIS vs. SPICE

Validation with large R_pkg on power/gnd pins

Oops! Missing something?
Workaround

Validation with R_pkg on power/gnd pins

RC De-coupling circuit added into IBIS simulations
Workaround

Validating with R_pkg on power/gnd pins – added RC de-coupling circuit

Voltage @ pad

Now they match!

Current @ vccq

Current @ vssq
Modeling On-Die De-Cap

- IBIS 5.0 model extracted using the static power supply
  - IBIS model data doesn’t contain any info about de-coupling circuit between Vccq and Vssq
  - There is no place for us to add this info into the [Model] section
- Solution within existing IBIS Specification
  - Use IBIS “Series” Model type (e.g. [C Series], [Rc Series]) to model de-coupling circuit
  - Use [Series Pin Mapping] to connect with Power and GND pins

There is a problem!
What is the issue?

- The Series Model de-coupling circuit attaches at the [Component] Pin level, not inside the [Model]
  - On-Die de-coupling circuit belongs to each buffer
  - In most cases, multiple buffers share one power/gnd rail
  - The only way to model per-buffer de-cap is with a per-power bus model. This might not be the desired de-cap model.
Conclusion

- IBIS 5.0 [Model] does not contain any info about decoupling between Power and GND nodes
- On-die de-coupling circuit can be added outside of IBIS [Model] to achieve accuracy requirement
- Be careful using IBIS [Series Pin Mapping] feature for On-die De-coupling Circuit modeling
- BIRD145 might provide a solution
  - Would allow complex on-die de-cap model attached to each [Model] and modeling of other important PDN parasitics
Thank You

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