APPROVED
by IBIS Open Forum

Update on BIRD223.1:
Add Support for SPIM in IBIS

- BIRD223 was approved on July 14, 2023
- BIRD223.1 was approved on November 17, 2023

SPIM = Streamlined Power Integrity Model

Kinger Cai, Chi-te Chen

May 2024

European Hybrid IBIS Summit
with IEEE SPI 2024
Lisbon, Portugal
May 15, 2024

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Presenter

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Kinger leads AI PC coherent architecture strategy in mobile platforms and drives strategic platform EDA tools & algorithms evolution in Intel. Kinger obtained Ph. D from Shanghai Jiao Tong University in 2001, and achieved MBA degree from W.P. Carey business school in ASU in 2008. Kinger has focused on signal & power integrity domains for 20+ years. Kinger holds 14 granted patents, and published 30+ papers.

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Executive Summary

Background:

- OEM/ODMs desire to design Time-To-Market innovative products effectively
- Platform PI design without standard model significantly lags SI design with IBIS
- SPIM expedites platform PI design while protecting chip vendor's IP

Timeline:

- PKG PI model was introduced with scalable platform PI design approach in 2018 *
- SPIM upon FastPI architecture got support with 3 EDA vendors in 2021
- SPIM draft initial version was brought up in IBIS ATM Group in 2022
- BIRD223, Add support for SPIM in IBIS, was submitted in March 2023
- BIRD223 got approved in IBIS Open Forum on July 14, 2023
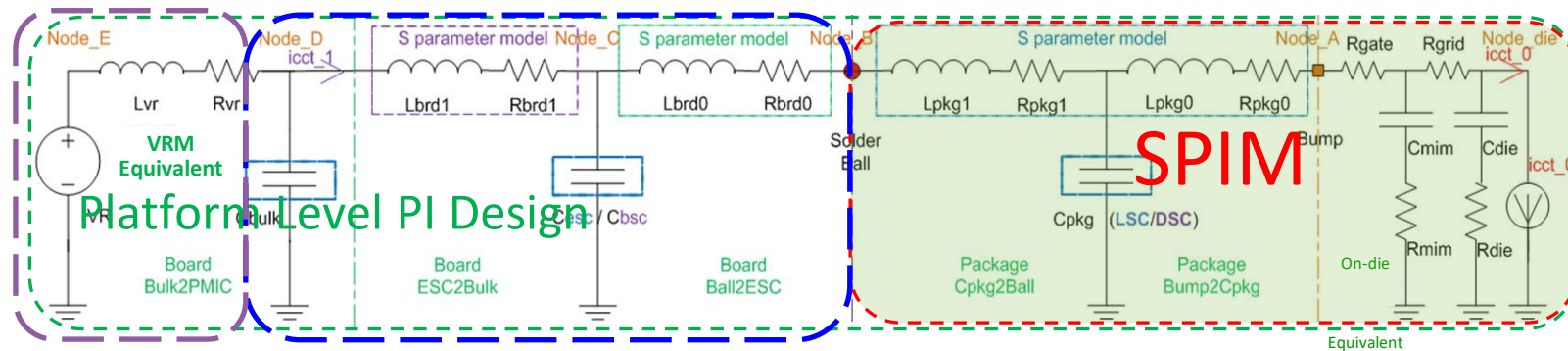- BIRD223.1 submitted on Sep. 12, 2023, and approved on Nov. 17, 2023
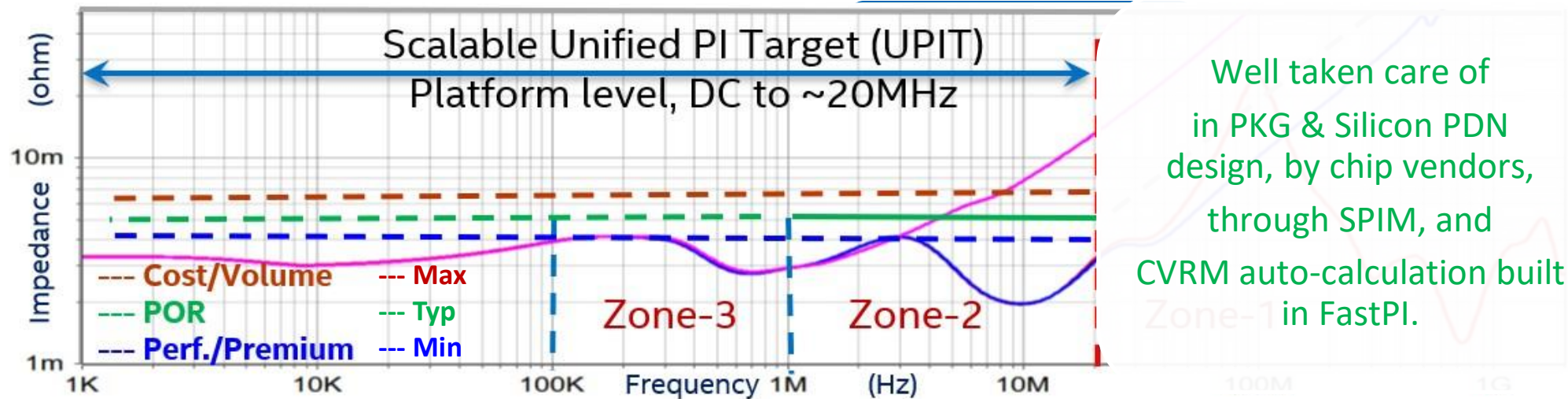
* IEEE Paper: Scalable Platform Power Integrity Design Approach with Standard PI Model (SPIM) and Unified PI Target (UPIT)
2018 IEEE International Symposium on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility (EMC/APEMC)
Xingjian Kinger Cai; Yun Ling; Steven Yun Ji; Jimmy Hsiao; Chi-te Chen; Denis Chen, page 64-66, 14-18 May 2018

Platform PI Design: SPIM- Streamlined PI Model

Well taken care of in PKG & Silicon PDN design, by chip vendors, through SPIM, and CVRM auto-calculation built in FastPI.

SPIM:
- S parameter
- Rnetwork (DC)
- Weighted source
- Defined target
- Pin awareness

- **SPIM:** Streamlined PI Model, for each power rail in a SoC/PKG, or a module.

Platform PI Design: Stimulus & Target Definition
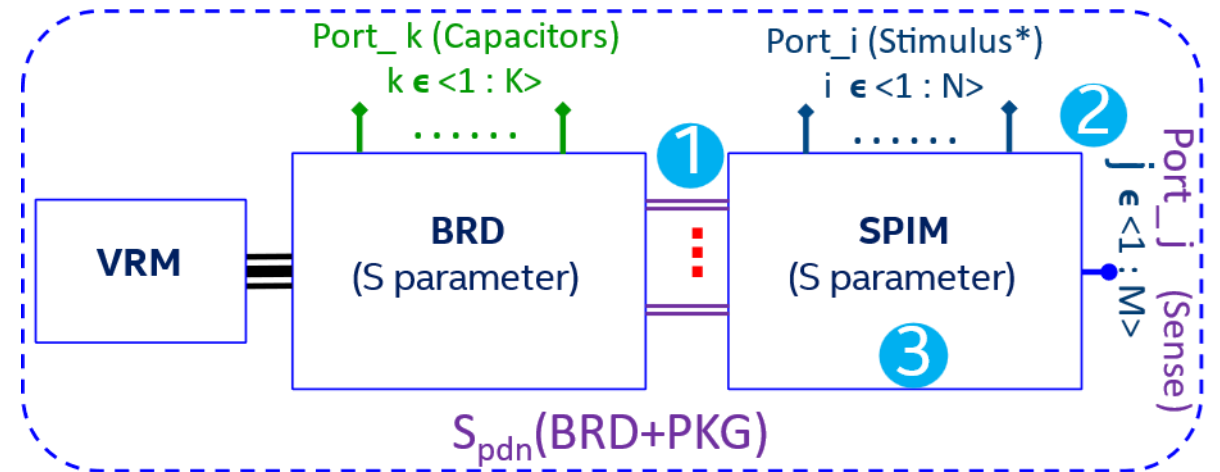
$$[S_{pdn}] \rightarrow [Z_{pdn}]$$

$$[V] = [Z_{pdn}][I]$$

$$[V] = [v_1, v_2, ..., v_N, v_{S1}, v_{S2}, ..., v_{SM}]^T$$

$$[I] = [W_1, W_2, ..., W_N, 0, 0, ..., 0]^T$$

$$\sum_{i=1}^{i=N} W_i = 1$$

$$Z_{Sj} = V_{Sj} = \sum_{i=1}^{i=N+M} (Z_{pdn(N+j),i} * W_i), \quad j\epsilon<1:M>$$

$$Z_{Sj} = \sum_{i=1}^{i=N} (Z_{pdn(N+j),i} * W_i), \quad j\epsilon<1:M>$$

Port_k (Capacitors) $k \in <1:K>$ — Port_i (Stimulus*) $i \in <1:N>$

VRM — **BRD (S parameter)** ① **SPIM (S parameter)** ② ③ — Port_j (Sense) $j \in <1:M>$

S_{pdn}(BRD+PKG)

**IEEE paper: VRM Modeling for Platform FastPI upon SPIM

2021 IEEE International Joint EMC/SI/PI and EMC Europe Symposium

Xingjian Kinger Cai; Wei Qian; Chi-te Chen; etc., page 162, August 2021

> **Impedance target is generally defined at the observing Port_ j.**

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Tree Structure of .spim FILE

```
.spim FILE
----------
  |-- File Header Section                                    |       |       |
  |   -------------------                                     |       |       |-- [SPIM Touchstone File]
  |     |-- [IBIS Ver]                                        |       |       |   --------------------------
  |     |-- [Comment Char]                                    |       |       |     |-- [SPIM Stimulus]
  |     |-- [File Name]                                       |       |       |     |   --------------
  |     |-- [File Rev]                                        |       |       |     |     |-- [End SPIM Stimulus]
  |     |-- [Date]                                            |       |       |     |-- [SPIM Target]
  |     |-- [Source]                                          |       |       |     |   -----------
  |     |-- [Notes]                                           |       |       |     |     |-- [SPIM Observation Port]
  |     |-- [Disclaimer]                                      |       |       |     |     |-- [End SPIM Target]
  |     |-- [Copyright]                                       |       |       |     |-- [End SPIM Touchstone File]
  |                                                           |       |       |
  |-- [Device SPIM]                                           |       |       |-- [SPIM Rnetwork File]
  |   ----------------                                        |       |       |   ------------------------
  |     |-- [Manufacturer]                                    |       |       |     |-- [SPIM Current]
  |     |-- [Description]                                     |       |       |     |   --------------
  |     |                                                     |       |       |     |     |-- [End SPIM Current]
  |     |-- [SPIM Rail]                                       |       |       |     |-- [SPIM Voltage List]
  |     |   -----------                                       |       |       |     |   --------------
  |     |     |-- [SPIM Pin Cluster]                          |       |       |     |     |-- [End SPIM Voltage List]
  |     |     |   -----------------                           |       |       |     |-- [End SPIM Rnetwork File]
  |     |     |     |-- [End SPIM Pin Cluster]                |       |       |     |
  |     |     |     |                                         |       |       |-- [End SPIM Rail]
  |     |     |-- [SPIM Port List]                            |       |
  |     |     |   ----------------                            |       |-- [End Device SPIM]
  |     |     |     |-- [End SPIM Port List]                  |
                                                              |-- [End]
```

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Linkage of .spim FILE to .ibs FILE

```
.ibs FILE
----------
   |
   |-- File Header Section
   |   ------------------
   |      |-- [IBIS Ver]
   |      |-- [Comment Char]
   |      |-- [File Name]
   |      |-- [File Rev]
   |      |-- [Date]
   |      |-- [Source]
   |      |-- [Notes]
   |      |-- [Disclaimer]
   |      |-- [Copyright]
   |
   |     … …
   |
   |-- [Component]
   |      |
   |      | … …
   |      |
   |      |-- [Device SPIM Group]
   |      |      |-- [End Device SPIM Group]
   |      |
   |      | … …
   |      |
```

Example:

```
[Device SPIM Group]  Group_name_1              | selector under [Component]
Device_SPIM_name_1    spim_folder/file_name_1.spim | it is in a .spim file
| …                                              RELATIVE to the .ibs file
| …
[End Device SPIM Group]


[Device SPIM Group]  Group_name_2              | selector under [Component]
Device_SPIM_name_2    spim_folder/file_name_2.spim | it is in a .spim file
| …                                              RELATIVE to the .ibs file
| …
[End Device SPIM Group]
```

Example .spim FILE - Supports PI AC Analysis

[SPIM Touchstone File]

```
| file_type file_reference

File_TS <path>Intel_CPU2_VCC3_PKG.s20p


|*** Here below explains how to use
*.snp s-element model in IBIS-ISS.
|.model pkg_model S N=20 tstonefile
|  ='Intel_CPU2_VCC3_PKG.s20p'
|S_one_ref
|+ OB_Stimulus_1
|+ OB_Stimulus_2
|+ OB_Stimulus_3
|+ OB_Stimulus_4
|+ OB_Stimulus_5
|+ OB_Stimulus_6
|+ OB_Stimulus_7
|+ OB_Stimulus_8
|+ OB_Sense
|+ BGA_1
|+ BGA_2
|+ BGA_3
|+ BGA_4
|+ BGA_5
|+ BGA_6
|+ BGA_7
|+ BGA_8
|+ BGA_9
|+ BGA_10
|+ BGA_11
|+ 0
|+ mname=pkg_model
```

[SPIM Stimulus]

```
|OB_Stimulus    Weighting

OB_Stimulus_1   0.20

OB_Stimulus_2   0.10

OB_Stimulus_3   0.05

OB_Stimulus_4   0.05

OB_Stimulus_5   0.20

OB_Stimulus_6   0.05

OB_Stimulus_7   0.05

OB_Stimulus_8   0.30
```

[End SPIM Stimulus]

[SPIM Target]

[SPIM Observation Port] OB_Sense

Z(Frequency)	Z(typ)	Z(min)	Z(max)
10000	0.0069	NA	NA
1000000	0.0069	NA	NA
6500000	0.0130	NA	NA
19000000	0.0285	NA	NA
40000000	0.0285	NA	NA

[End SPIM Target]

[End SPIM Touchstone File]

OB_Sense

VRM — Motherboard

BGA_1, BGA_2, BGA_3, BGA_4, BGA_5, BGA_6, BGA_7, BGA_8, BGA_9, BGA_10, BGA_11

*.s20p

OB_Stimulus_1 0.20
OB_Stimulus_2 0.10
OB_Stimulus_3 0.05
OB_Stimulus_4 0.05
OB_Stimulus_5 0.20
OB_Stimulus_6 0.05
OB_Stimulus_7 0.05
OB_Stimulus_8 0.30

Example Deck — Impedance_Target

0.0285 Ohm @20MHz

0.013 Ohm @6.5MHz

0.069Ohm @1MHz

Impedance (Ohm) vs Frequency (Hz)

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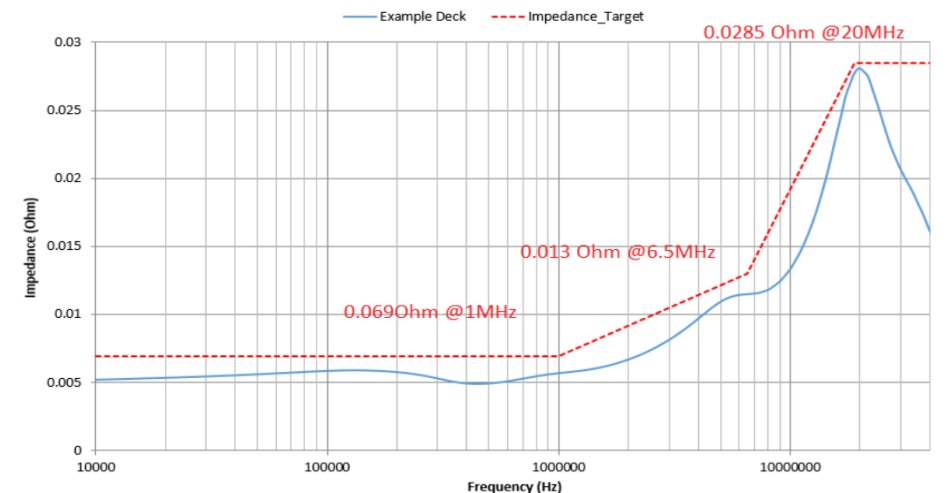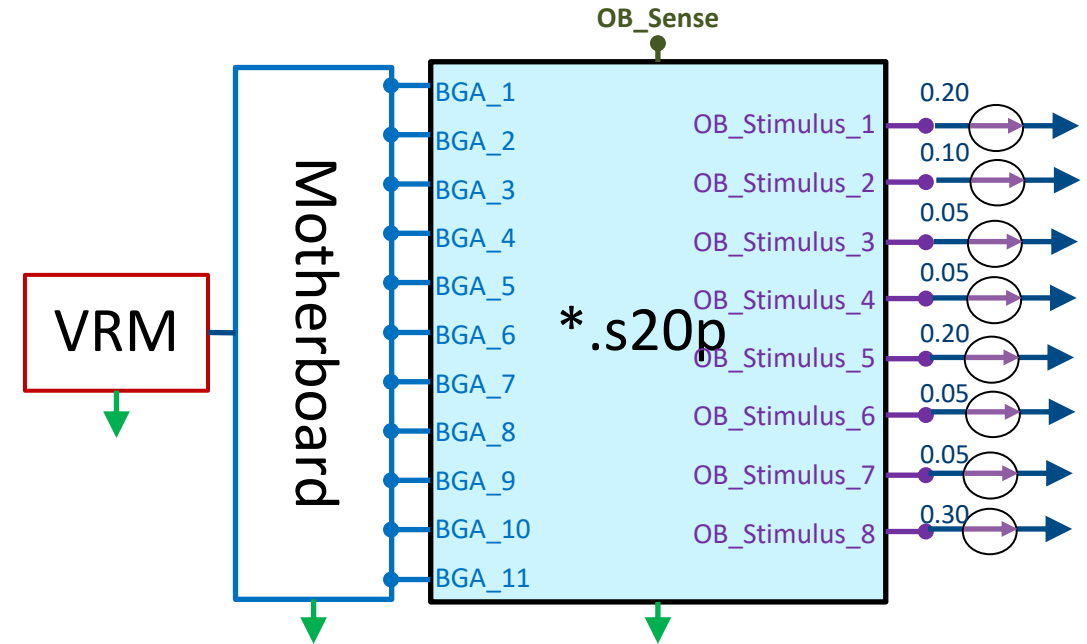
Example .spim FILE   - Supports Power DC Analysis

```
[Rnetwork File]
| file_type file_reference
File_IBIS_ISS <path>My_CPU2_VCC3_PKG_Rnetwork.ckt
| …
[End SPIM Rnetwork File]
|
[SPIM Current]
| I(name)     I(typ)      I(min)        I(max)
VCC           4.50        NA            7.50
[End SPIM Current]
|
|************************************************
[SPIM Voltage List]
| V(name)     V(typ)       V(min)        V(max)
VCC           1.000        0.900         1.100
[End SPIM Voltage List]
|
|************************************************
[End SPIM Rail]       | VCC
|************************************************
[End Chip SPIM]       | Intel_CPU3
```
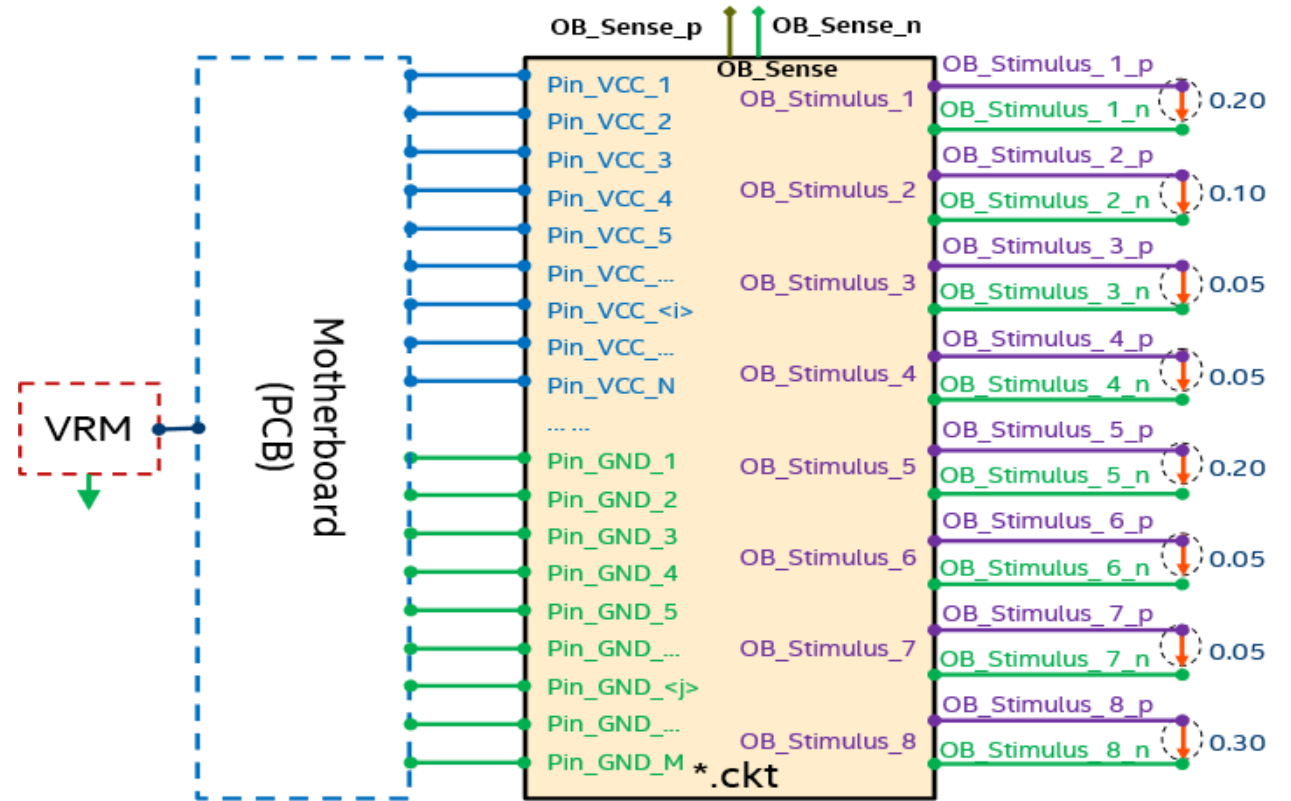

To Achieve:

- Most accurate per-pin current distribution
- Most accurate per-pin voltage droop map
- Most accurate Board level full PD analysis

BIRD223.1 Update from BIRD223

1) Corrected the over-sighted editorial typo error of [Device Model] to [Device SPIM].

2) Updated [Device SPIM] to "Required in a .spim file, illegal in a .ibs file" in Table 2.

3) Simplified the description by eliminating the redundancy and updated for keyword: [Device SPIM], according to item#2.

4) Updated the description and example of the keyword [Device SPIM Group], according to item#2.

5) Updated "standard" to "streamlined" for the "S" in SPIM.

6) Simplified description for adding [Device SPIM Group] & [End Device SPIM Group] keyword pair, into the "tree" of .ibs file.

7) Corrected some minor editorial typo errors & wording format.

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FastPI (Platform PI Arch. with SPIM) Roadmap

Customer Database
(customer)

SPI Models
(Chip vendors)

C/L/D/R/S models
(customer/vendors)

VR model
(Auto-cal./Vendor)

SPIM works standalone, and/or also together with all IBIS Power models of Capacitor/Inductor/Diode/Resistor

FastPI
(Platform PI design Framework)
Calling for major EDA vendors.

User friendly
EDA ecosystem
well established!

AC analysis
(Review & Sign-off)
Version-1

Capacitor optimization
for cost-optimal PDN

DC analysis
(Review & Sign-off)
Version-2

Transient analysis
(Validation/VRTT)
Version-3

IEEE Paper: Scalable Platform Power Integrity Design Approach

with Standard PI Model (SPIM) and Unified PI Target (UPIT)

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Next Steps:

- Example .spim file for golden example available in Q2'2024

- Example .spim file for LPDDR5X Device available in Q2'2024

- Cookbook Rev1.0 for SPIM Ver1.0 available in Q3'2024

- BIRD223.1 integration into a future release of the IBIS Specification

- SPIM parser available in a future release of IBISCHK

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BIRD223.1 Update -1

1) Corrected the over-sighted editorial typo error of [Device Model] to [Device SPIM].

Keyword: **[Manufacturer]**

Required: No.

Description: Specifies the name of the [Device ~~Model~~ SPIM] manufacturer.

Usage Rules: The length of the manufacturer's name shall not exceed 40 characters, while blank characters are allowed.

Example:

[Manufacturer] MyName Corp.

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BIRD223.1 Update from BIRD223 -2

1) Corrected the over-sighted editorial typo error of [Device Model] to [Device SPIM].

2) Updated [Device SPIM] to "Required in a .spim file, illegal in a .ibs file" in Table 2.

Table 2 – SPIM Keywords and Subparameters

Keywords or subparameters	Notes
[Device SPIM Group]	Optional in a .ibs file, illegal in a .spim file
[Device SPIM]	~~Optional in a .ibs file, required~~ Required in a .spim file, illegal in a .ibs file
[Manufacturer]	Optional within any [Device SPIM]

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BIRD223.1 Update from BIRD223 -3

1) Corrected the over-sighted editorial typo error of [Device Model] to [Device SPIM].

2) Updated [Device SPIM] to "Required in a .spim file, illegal in a .ibs file" in Table 2.

3) Simplified the description by eliminating the redundancy and updated for keyword: [Device SPIM], according to item#2.

Keyword: **[Device SPIM]**

Required: No, but it is required in a .spim file.

Description: Marks the beginning of device level SPIM for a particular device or module. ~~The [Device SPIM] keyword is only defined once in a .ibs file or in a .spim file.~~

Usage Rules: The [Device SPIM] keyword accepts a single string argument which is a ~~device~~Device SPIM name. This string argument shall be no longer than 40 characters and shall not include whitespace.

The [Device SPIM] / [End Device SPIM] keyword pair shall appear only once in a .spim file for one ~~particular~~ device or module~~. The device~~, with a unique Device SPIM name ~~in a given .spim file shall be unique~~.

All content, defined between [Device SPIM] and [End Device SPIM] keyword pair in a .spim file, shall ~~be able to~~not be copied ~~and~~or inserted into a .ibs file of the same [Component~~] or being~~], instead should be called by Device SPIM name between the [Device SPIM Group] ~~/~~and [End Device SPIM Group] keyword pair in a .ibs file.

BIRD223.1 Update from BIRD223 -4

1) Corrected the over-sighted editor

2) Updated [Device SPIM] to "Requi

3) Simplified the description by elim
   SPIM], according to item#2.

4) Updated the description and example of the keyword [Device SPIM Group], according to item#2.

Keyword: **[Device SPIM Group]**

Required: No, but it is required for including an SPIM model in a .ibs file.

Description: In a .ibs file, a selector under [Component] to select the device SPIM models, which are ~~either directly included in the same .ibs file or~~ in a separate .spim file. In a .ibs file, the [Device SPIM Group] keyword is permitted multiple times.

The [Device SPIM Group] keyword is used to define a list of [Device SPIM] models by name that shall be used together for all concerned power rails of one particular configuration on a platform.

Usage Rules: The [Device SPIM Group] keyword accepts a single string argument, which is device SPIM group name. The string argument shall be no longer than 40 characters and shall not include whitespace.

For each existing [Device SPIM Group], there are usually two columns. The first column lists the Device SPIM name uniquely in string argument one by one, each of them shall be no longer than 40 characters and shall not include whitespace. ~~The second column is "NA", if the referred Device SPIM model is defined in the same .ibs file. Otherwise, the~~ The second column refers to the relevant .spim file name, either in the same folder of the local .ibs file or a spim_folder, a subfolder underneath the folder where the local .ibs file is located, will be specified.

Example:
```
[Device SPIM Group]    Group_name_1                | selector under [Component]
|  ...
Device_SPIM_name_1    NA                           | if it is in the .ibs file
Device_SPIM_name_2    NA                           | if it is in the .ibs file
|  ...
Device_SPIM_name_3    spim_folder/file_name_1.spim | if it is in a .spim file.
|  ...                                               RELATIVE to the .ibs file
|  ...
[End Device SPIM Group]
```
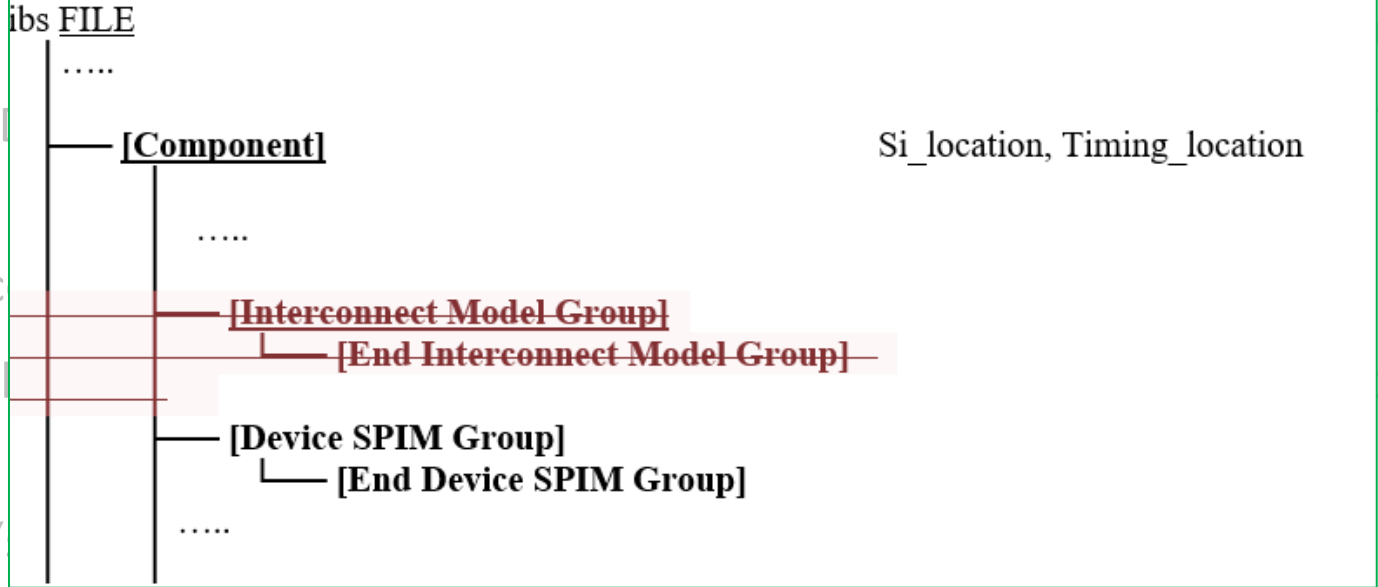
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BIRD223.1 Update from BIRD223 -5

1) Corrected the over-sighted editorial typo error of [Device Model] to [Device SPIM].

2) Updated [Device SPIM] to "Required in a .spim file, illegal in a .ibs file" in Table 2.

3) Simplified the description by eliminating the redundancy and updated for keyword: [Device SPIM], according to item#2.

4) Updated the description and example of the keyword [Device SPIM Group], according to item#2.

5) **Updated "standard" to "streamlined" for the "S" in SPIM.**

Table 1: Solution Requirements

Requirements	Notes
To enable platform level PI design with SPIM using published platform PI design architectures, the IBIS specification is extended to define the ~~Standard~~Streamlined PI Model (SPIM).	

BIRD223.1 Update from BIRD223 -6

Add to ibs FILE [Device SPIM Group] under [Component] after [Interconnect Model Group]:

ibs FILE
.....
— [Component]
.....
[Interconnect Model Group]
— [End Interconnect Model Group]
— [Device SPIM Group]
└── [End Device SPIM Group]
.....

Si_location, Timing_location

1) Corrected ...ce SPIM].

2) Updated [... Table 2.

3) Simplified ... keyword: [Device SPIM], acc...

4) Updated t...], according to item#2.

5) Updated "...

6) Simplified description for adding [Device SPIM Group] & [End Device SPIM Group] keyword pair, into the "tree" of .ibs file.