

Computer-Assisted Modeling of Digital I/O Buffers for IBIS

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Discussion within CPMT – TC12

Electrical Design, Modeling and Simulation (EDMS, TC-12) sub-committee

<http://www.ewh.ieee.org/soc/cpmt/tc12/>

- ❖ **EDMS sub-committee works on the standardization of design tools and design methodologies in packaging**

- ❖ **Initiative for “Practical Macromodels for Digital I/O”**

→ First meeting @ EPEP, Oct. 2004 in Portland, Oregon, USA.

http://www.ewh.ieee.org/soc/cpmt/tc12/standardization_files/IBIS_TC12a.ppt

SPI (Signal Propagation on Interconnects) IEEE Workshop,
May. 10-13, 2005 in Garmisch-Partenkirchen, Germany
(c.f.p. at <http://www.spi.uni-hannover.de/>)

I/O Buffers Macromodeling

- **Required Goals:**
 - **IP protection**
 - **Vendor-independent** format
 - Have to capture TX, RX, and package parasitic essentials
 - Sufficiently accurate to be useful
 - **Easy to automatically generate** from Spice and Measurements
 - Easy to verify
 - Easy and fast to simulate

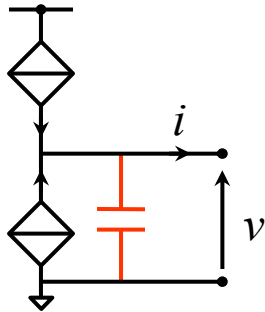
I/O Buffers Macromodeling

Current status



Circuit-based modeling

(native IBIS)



- standard,
- large data/model libraries,
- EDA tools support...

specification and tools from
<http://www.eigroup.org/ibis/>

Black-box modeling

$$i = F(v, d/dt)$$

...aimed at improving the modeling of latest technologies and high-order effects

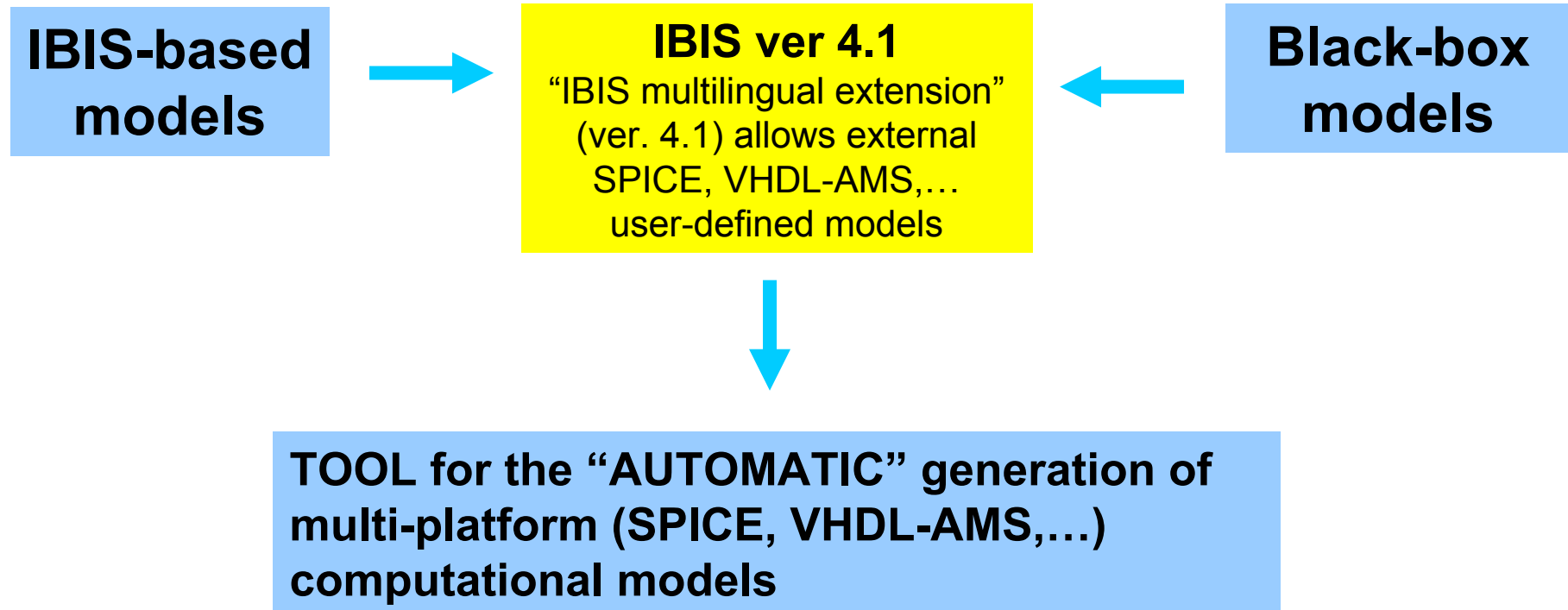
- LVDS drivers with pre-emphasis
- DDR memories,
- power supply ports...

e.g., parametric modeling



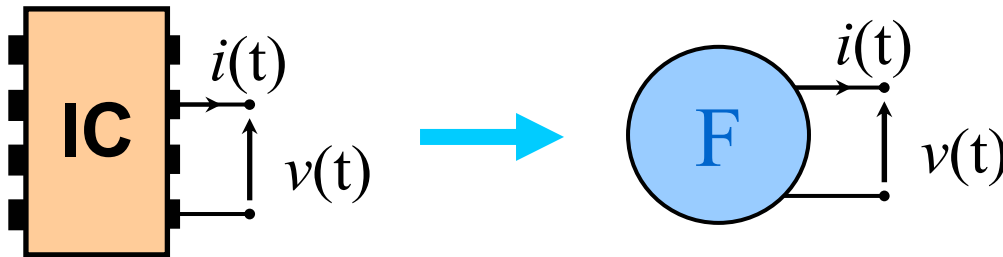
I/O Buffers Macromodeling

The way forward



Black-box modeling @ Politecnico di Torino

$M\pi log^{\circledR}$ (Macromodeling via parametric identification (π) of logic gates): **Method & Tool**



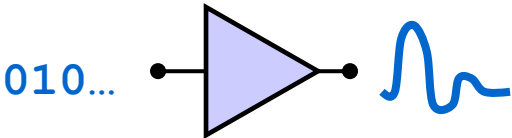


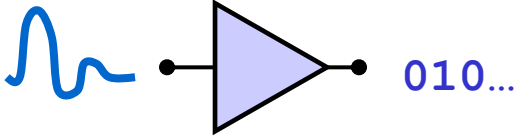


$$i(k) = \mathbf{F}(\Theta, [i(k-1), \dots, i(k-r), v(k), \dots, v(k-r)])$$

↑
 Σ nonlinear basis functions



Model parameters (Θ) via system identification methods

Mπlog features

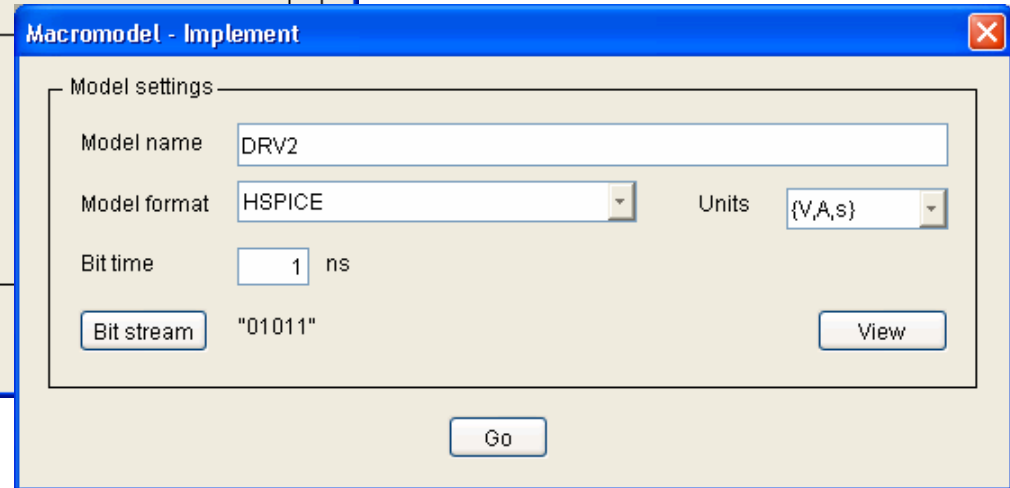
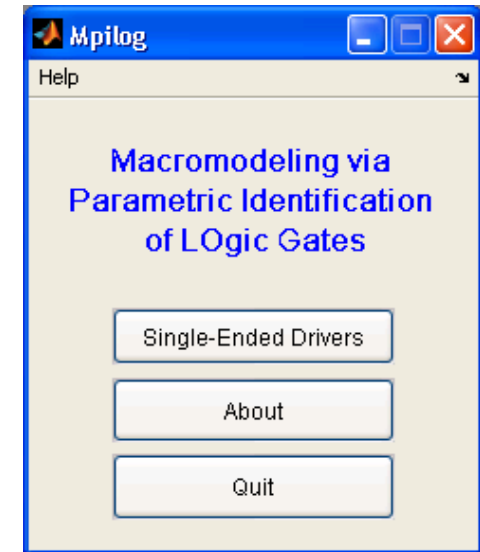
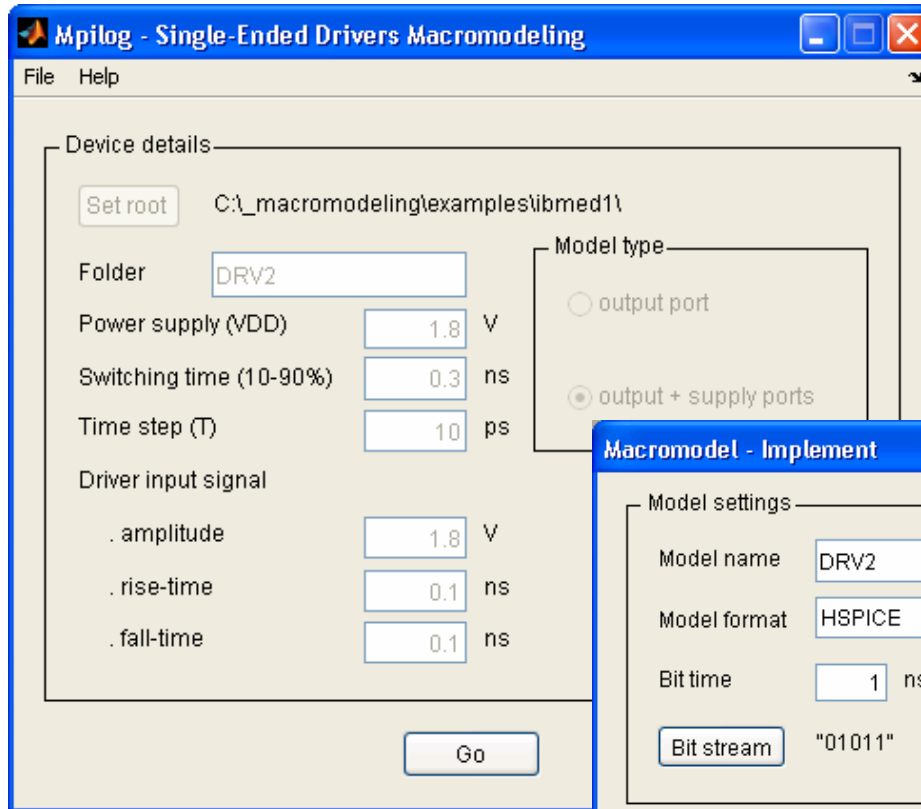
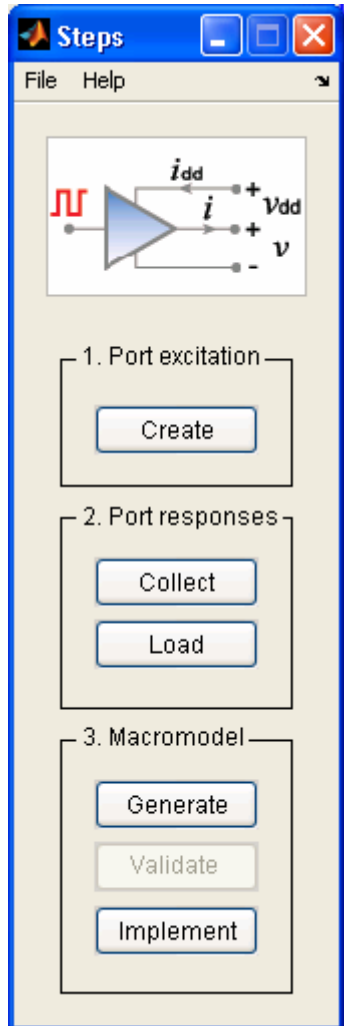
		Single-Ended	Differential
<u>Drivers</u>			
<u>Receivers</u>			

+ {

 Power Supply ports

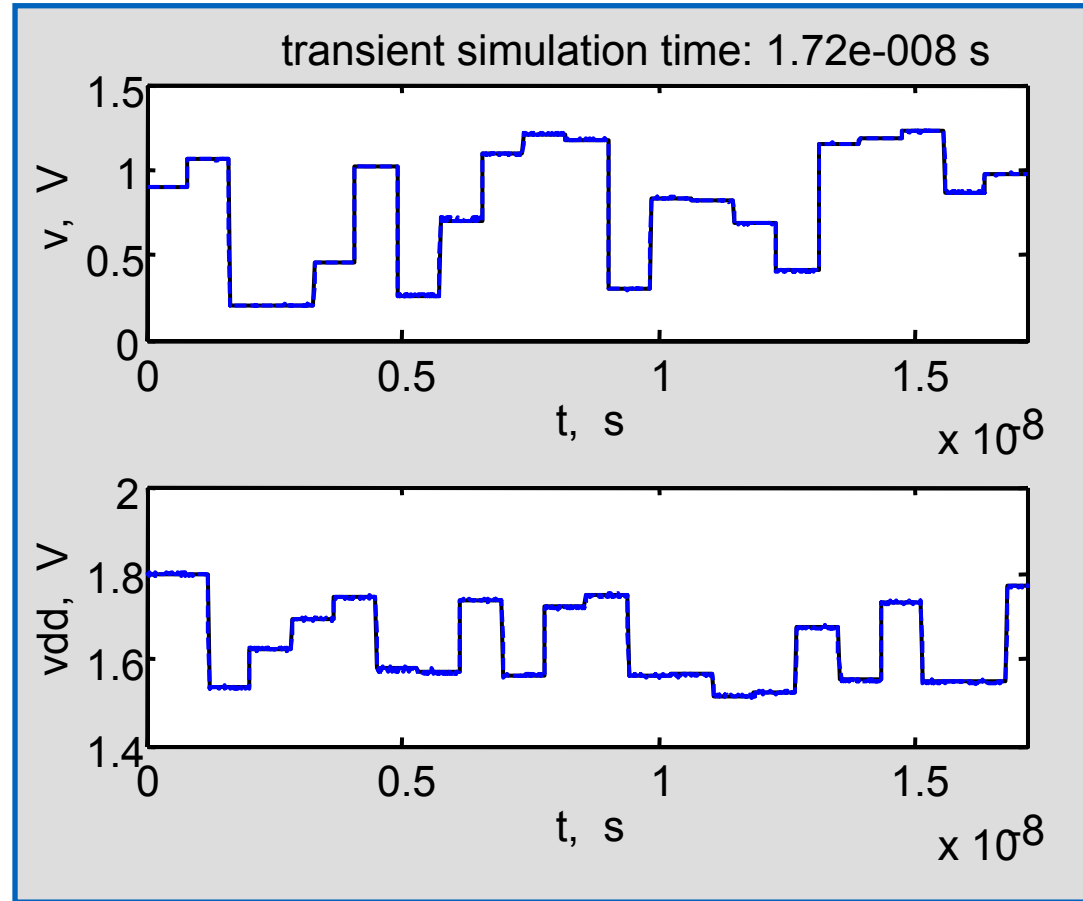
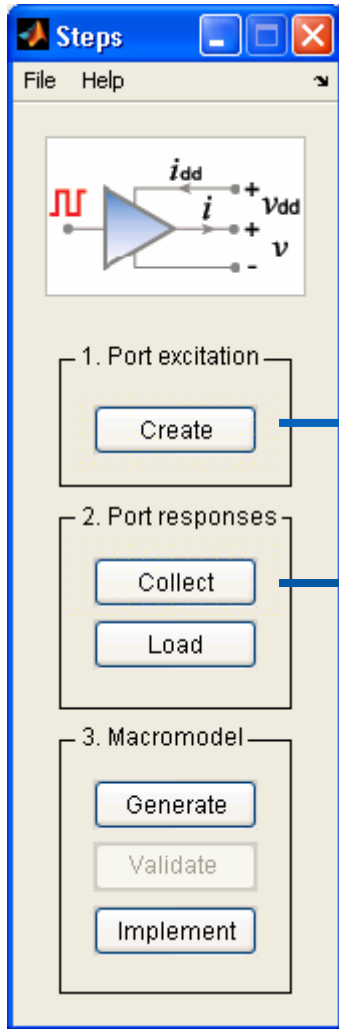
 Temperature effects

Mπlog Tool



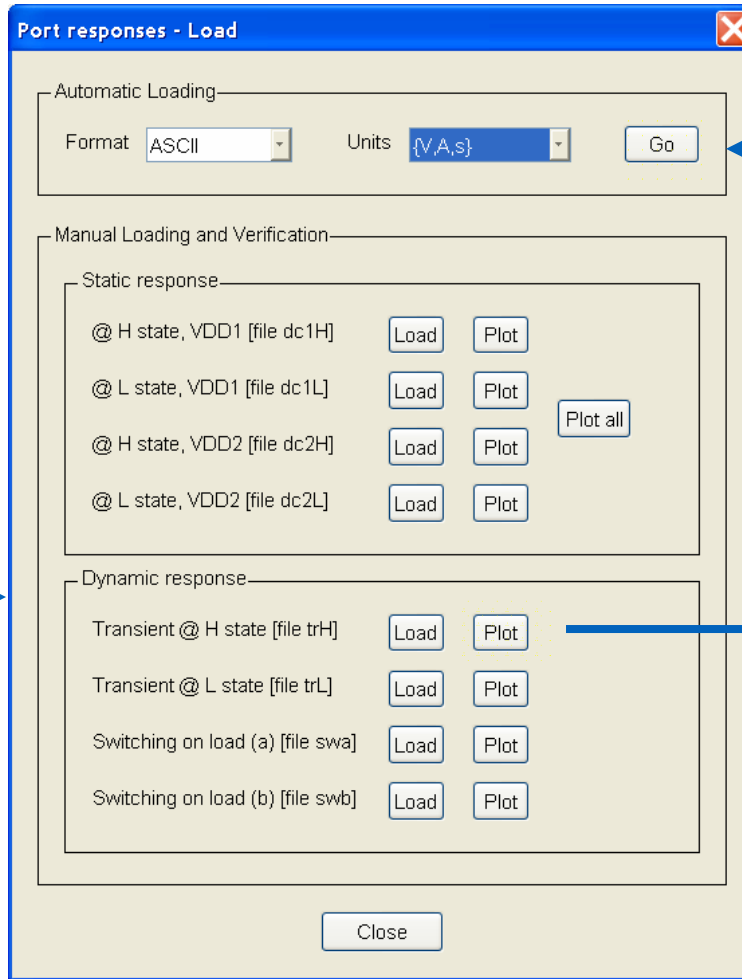
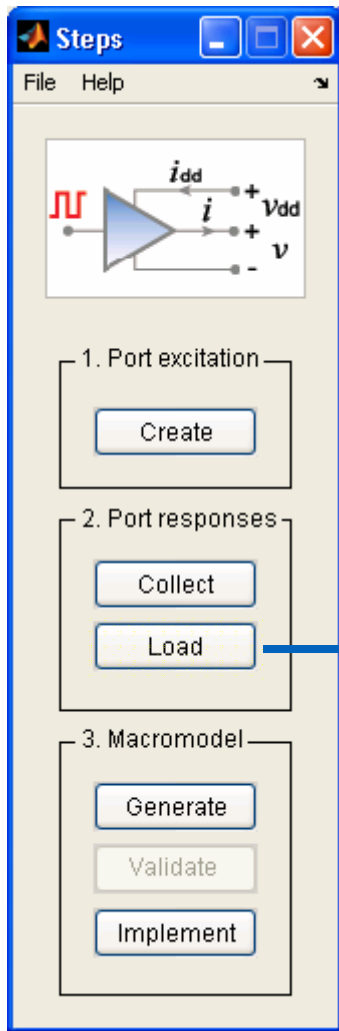
Tool available on request (igor.stievano@polito.it)

Mπlog Tool

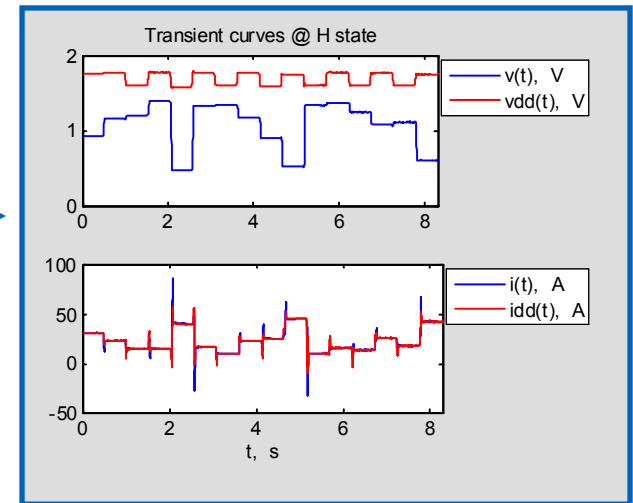


RUN YOUR PREFERRED CIRCUIT SOLVER (e.g. SPICE)

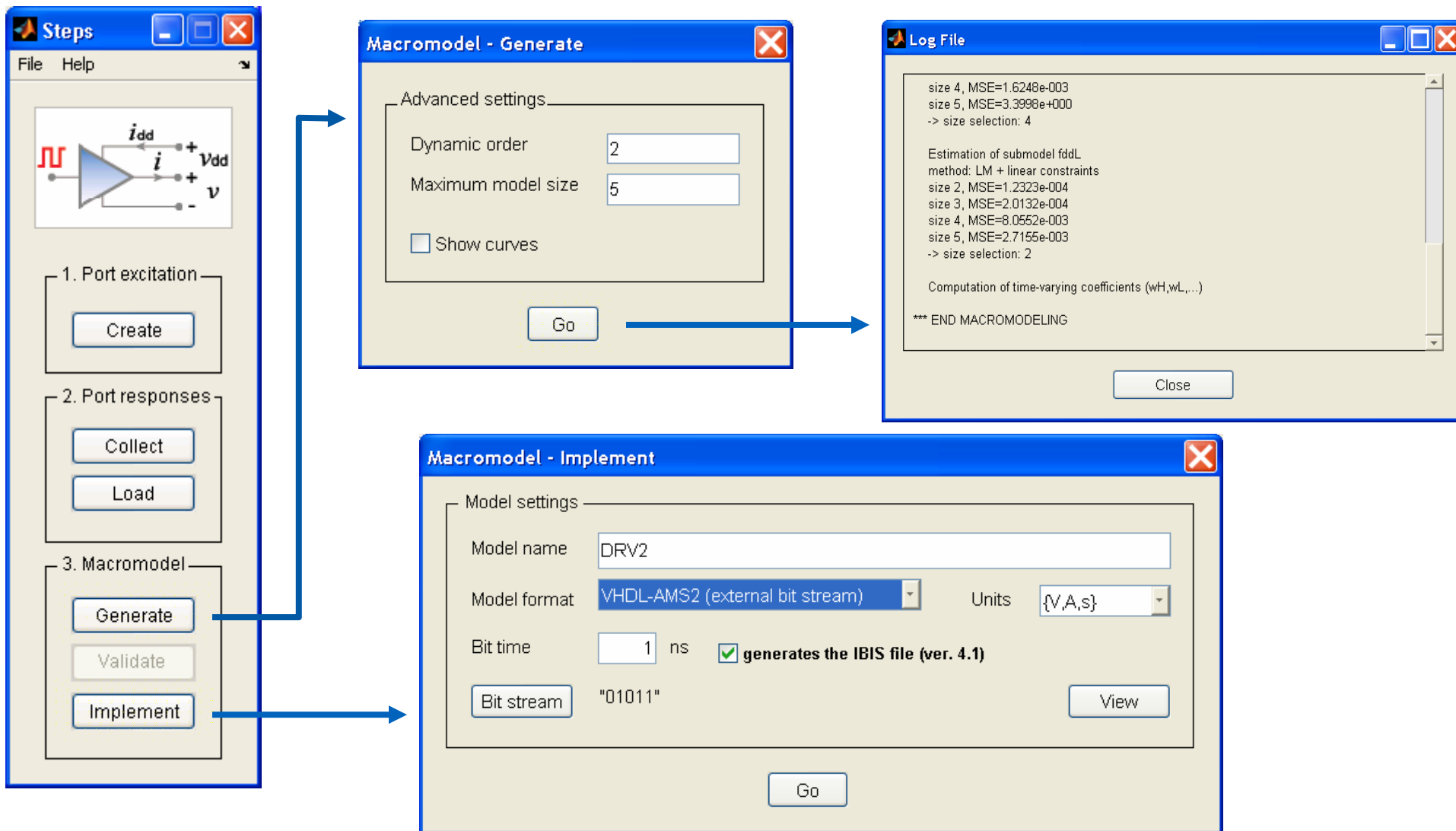
Mπlog Tool



AUTO LOADING



Mπlog Tool



Conclusions (i)

- 😊😊 – **IP protection**
- 😊😊 – **Vendor-independent** format
- 😊😊 – Have to capture TX, RX, and package parasitic essentials
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Conclusions (ii)


Black-box models are expressed by equations that are used **as they are**, without any interpretation

- ❖ **no data to model conversion needed**
- ❖ **flexible modeling methods**
- ❖ **model enhancements do not affect IBIS and IBIS simulator structures**

The distribution of black-box models would be a valuable complement to the distribution of behavioral data

Acknowledgements

Thanks to

- ❖  for providing the Analog/Mixed-Signal simulator environment (**ADVance MS™ + Eldo™**)
- ❖ **Sergio Perazza** (Mentor, Italy) for the technical support on Mentors' products
- ❖ **Arpad Muranyi** (Intel) for VHDL templates and code posted on <http://www.eda.org/pub/ibis/summits/jun03a/> and <http://www.eda.org/pub/ibis/summits/feb04a/>