More on C_comp:

How to represent C_comp in IBIS buffer model

European IBIS Summit

SPI 2010 - Hildesheim, Germany

May 12, 2010

Copyright © 2006-2010
IO Methodology Inc.

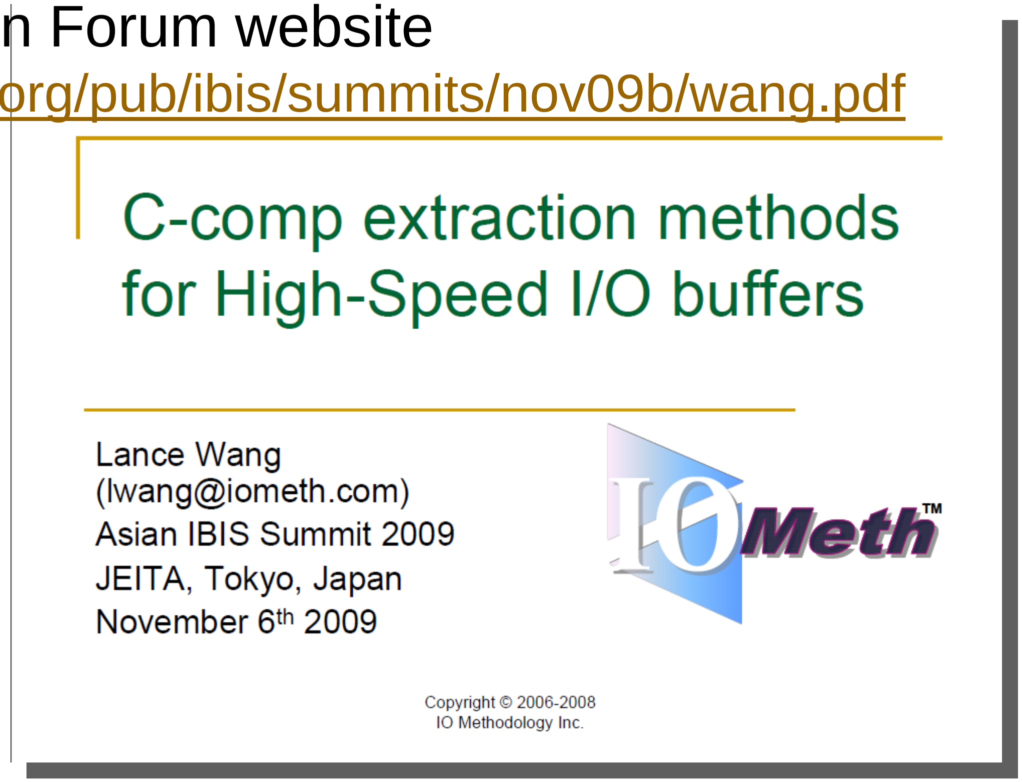
Outline

- C_comp extraction method
  - Review of last presentation in Asia IBIS Summits
- Methods for representing die-capacitance in IBIS buffer model
  - Test cases
- Conclusions and suggestions

Copyright © 2006-2010
IO Methodology Inc.

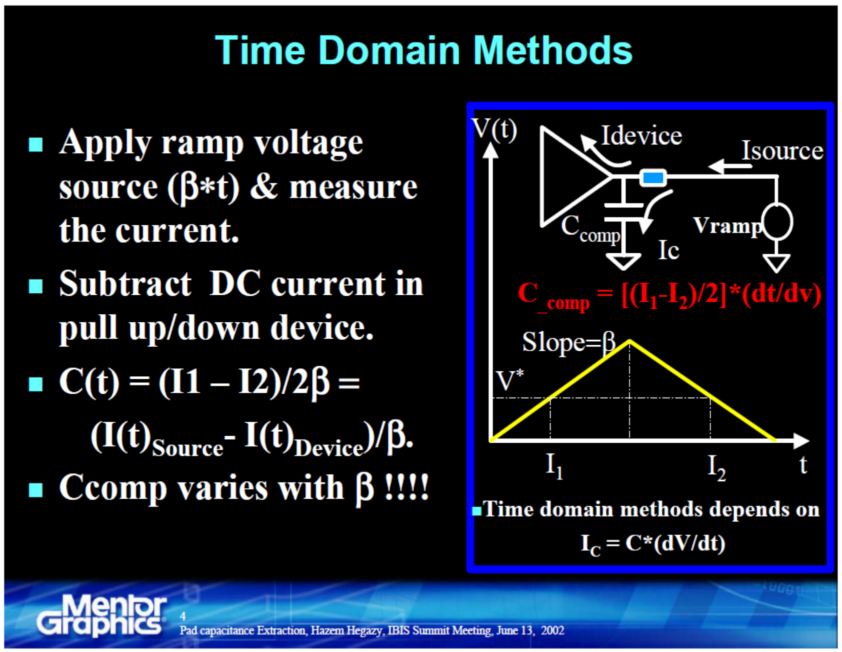
C_comp extractions

- Review of last C_comp presentation for extraction methods
  - Presented in Asia IBIS Summits (Japan and China) 2009
  - Links in IBIS Open Forum website
    - http://www.vhdl.org/pub/ibis/summits/nov09b/wang.pdf

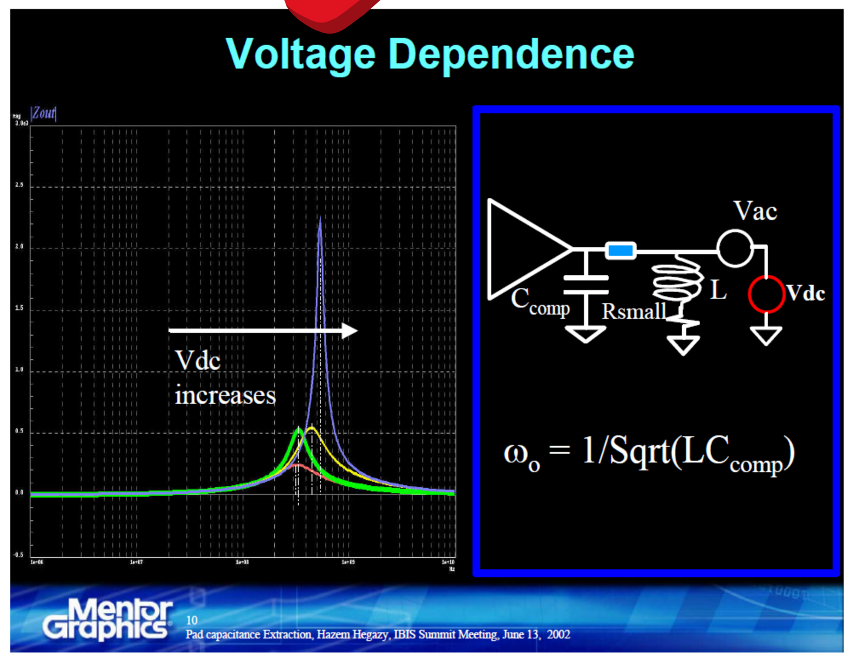


Copyright © 2006-2010
IO Methodology Inc.

Time and Frequency Domain methods



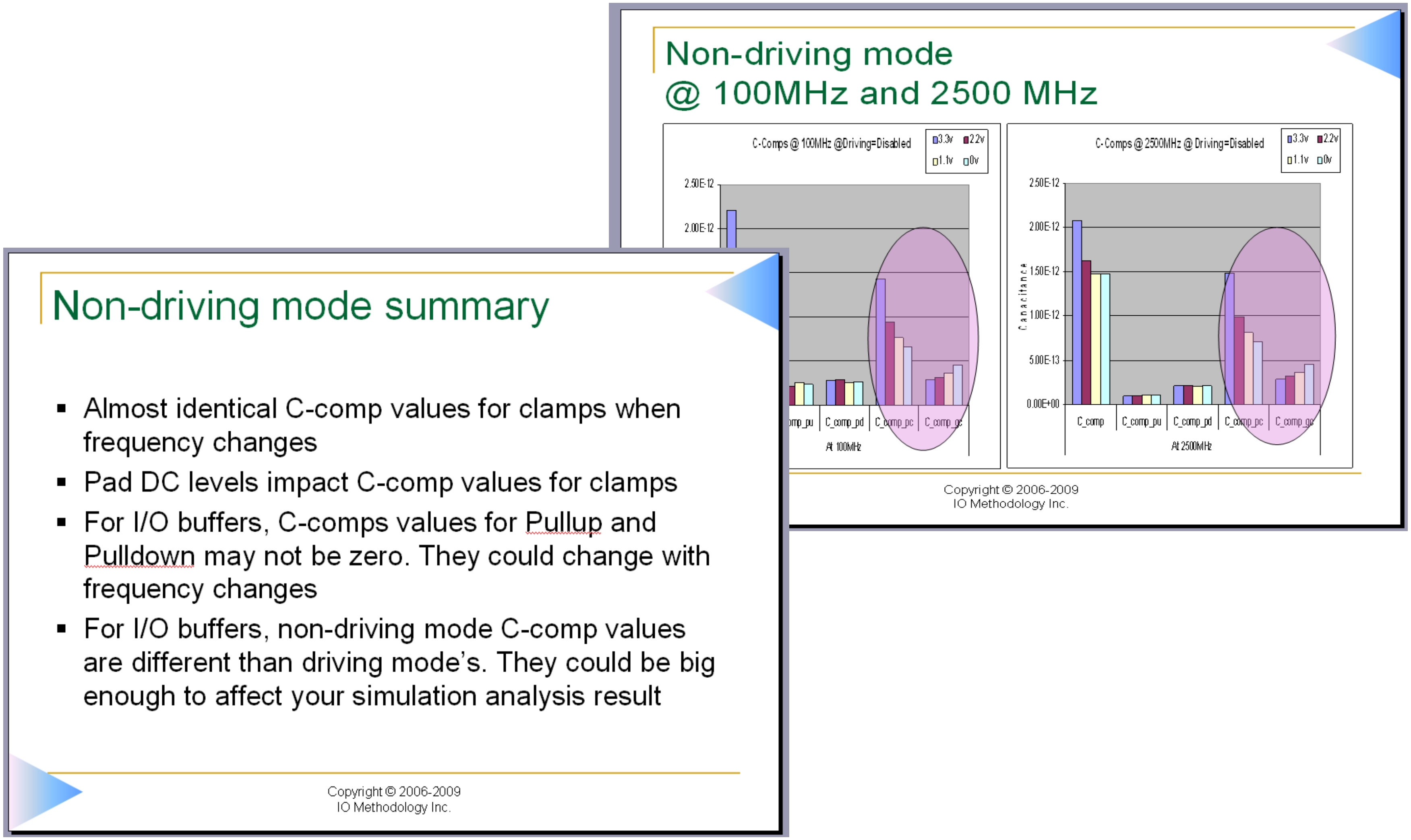
Time Domain



Frequency Domain

Copyright © 2006-2010
IO Methodology Inc.

Non-driving / Receiving mode



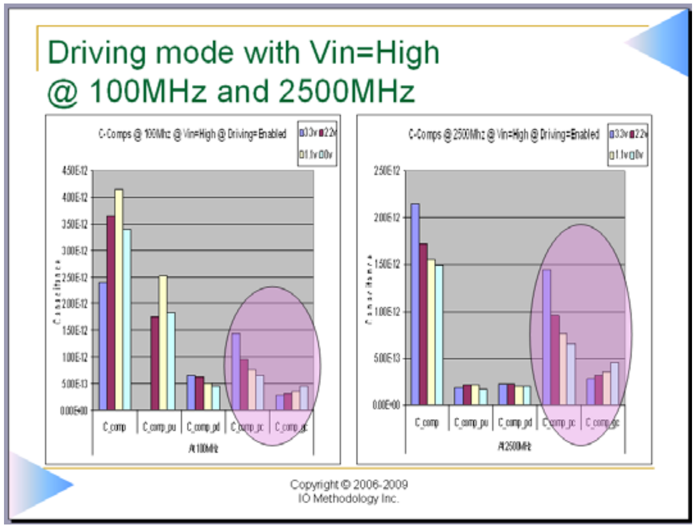
Non-driving mode summary

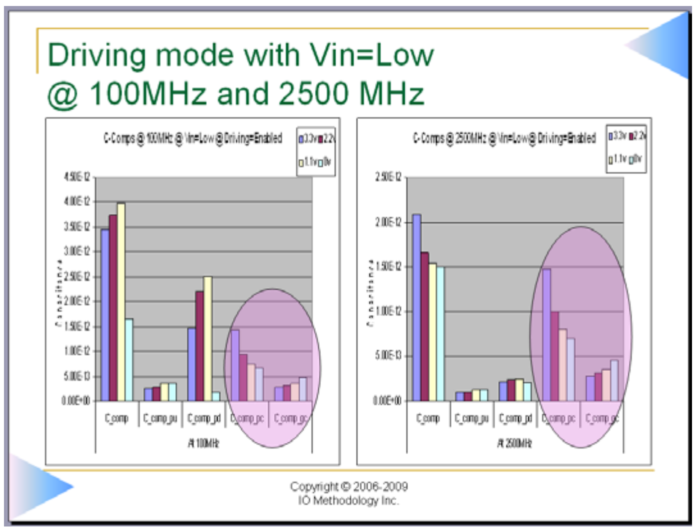
- Almost identical C-comp values for clamps when frequency changes
- Pad DC levels impact C-comp values for clamps
- For I/O buffers, C-comps values for Pullup and Pulldown may not be zero. They could change with frequency changes
- For I/O buffers, non-driving mode C-comp values are different than driving mode's. They could be big enough to affect your simulation analysis result

Copyright © 2006-2009
IO Methodology Inc.

Copyright © 2006-2010
IO Methodology Inc.

Driving Mode





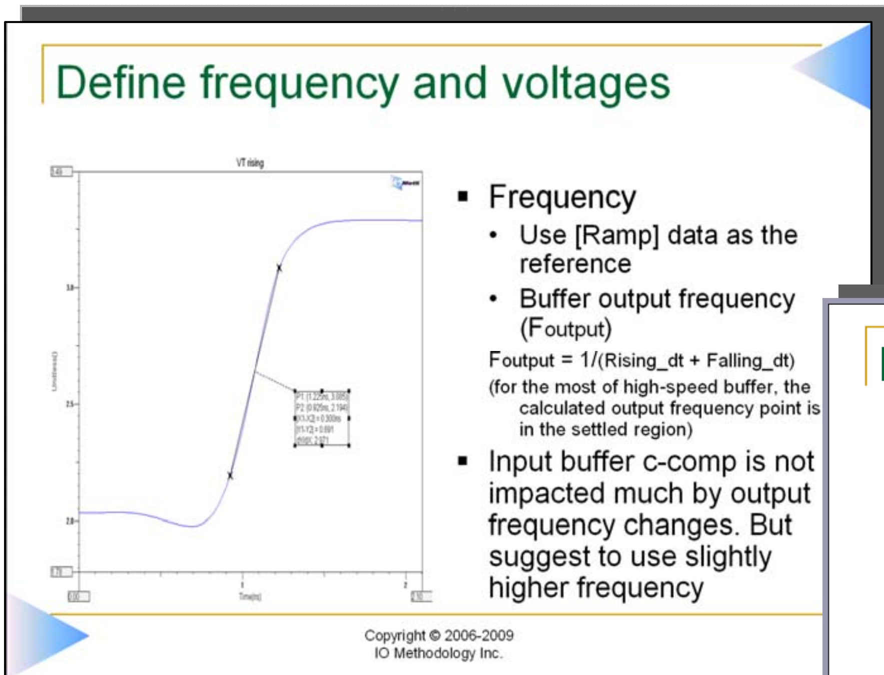
Driving mode summary

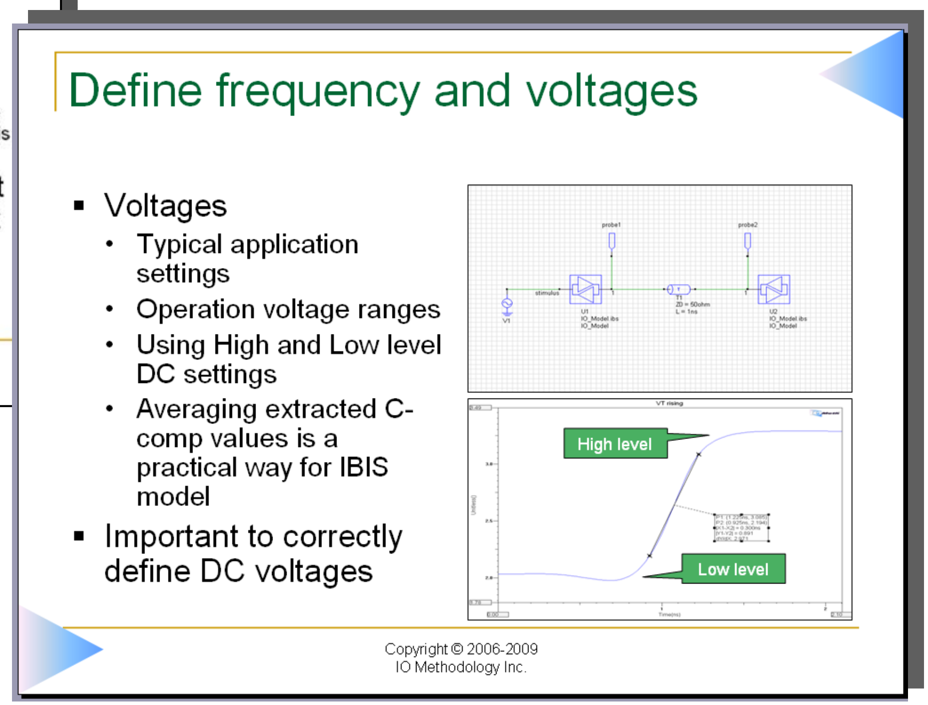
- Identical C-comp values for clamps with frequency changes
- Pad DC levels impact C-comp values for clamps
- Pullup and Pulldown C-comp values vary with frequency changes. But it settles at a frequency point and up (being flat)
  - Input DC (level = High) impacts more on Pullup
  - Input DC (level = Low) impacts more on Pulldown

Copyright © 2006-2009
IO Methodology Inc.

Copyright © 2006-2010
IO Methodology Inc.

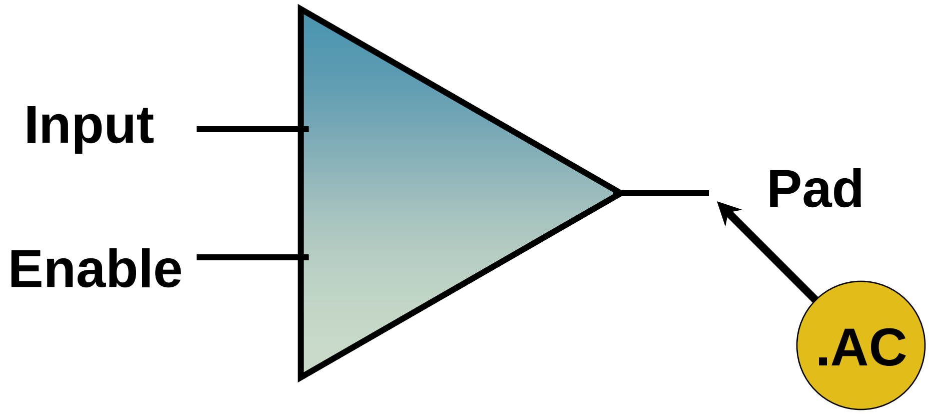
Extract C_comp with expected Frequency and Voltage





Copyright © 2006-2010
IO Methodology Inc.

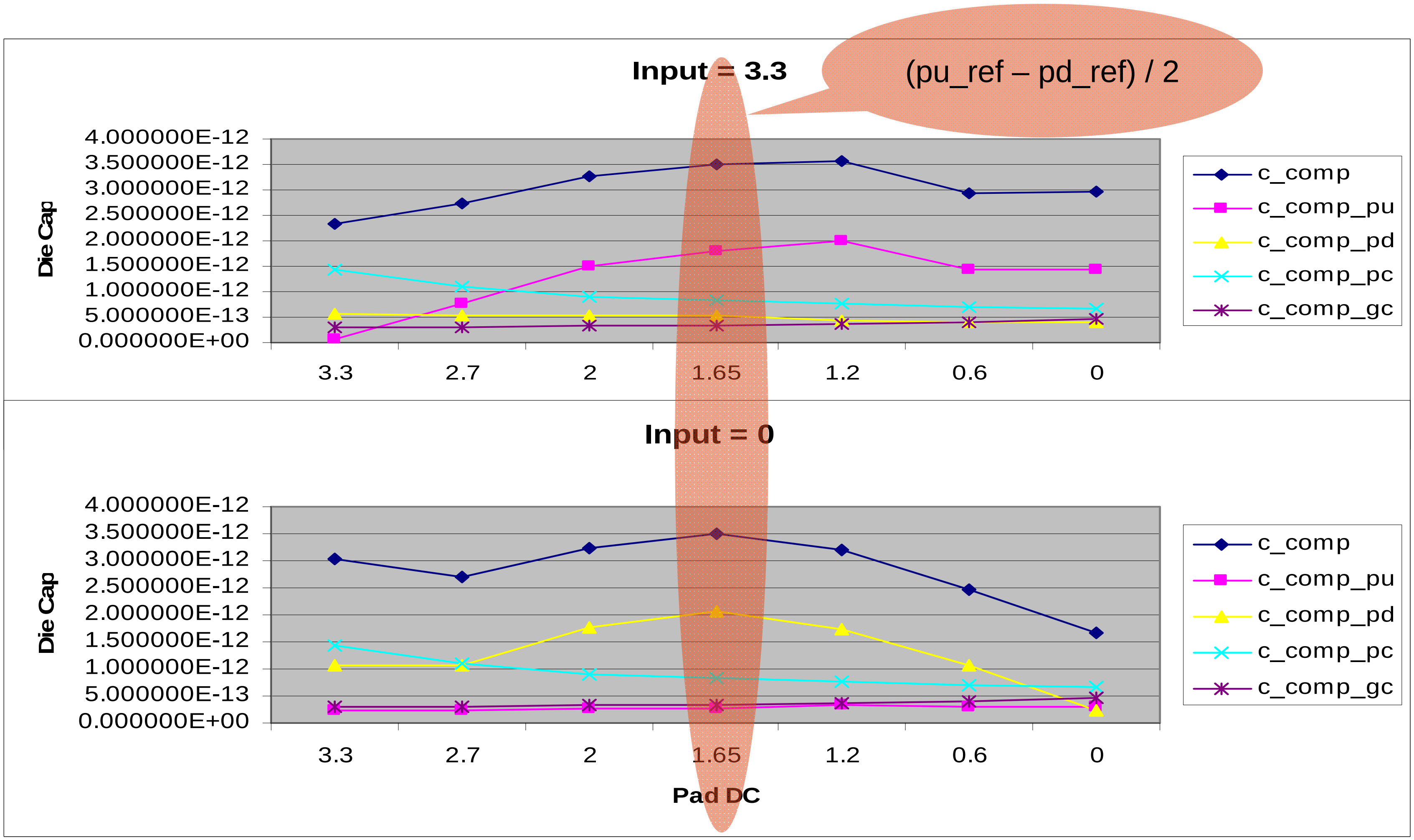
Methods for representing die-capacitance in IBIS buffer model



- A test case
  - Input=3.3
    - Pad DC=3.3, 2.7, 2, 1.65, 1.2, 0.6, 0
  - Input=0
    - Pad DC=3.3, 2.7, 2, 1.65, 1.2, 0.6, 0

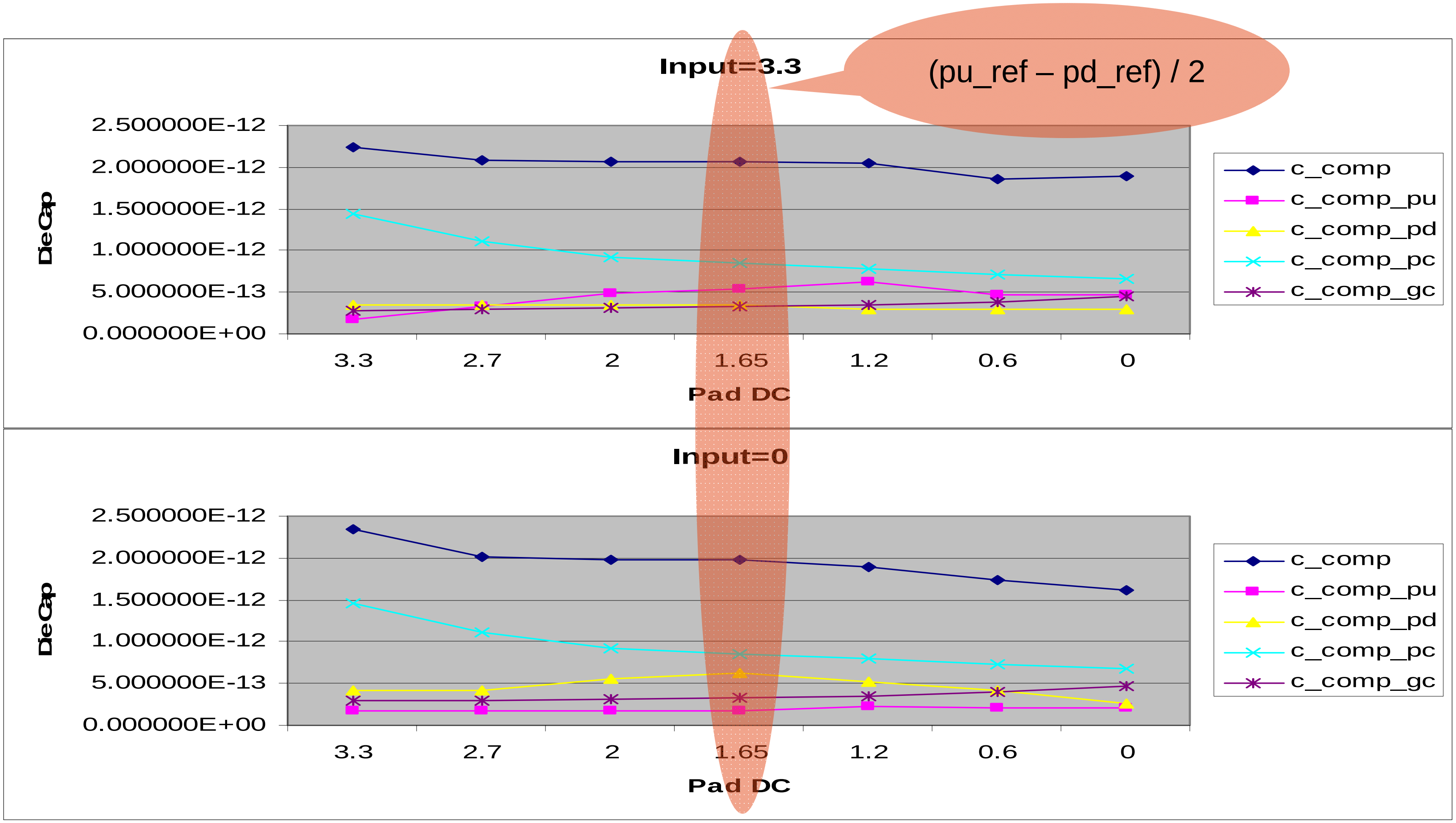
Copyright © 2006-2010
IO Methodology Inc.

Extracted C_comp values for different Pad DC settings @ 180MHz



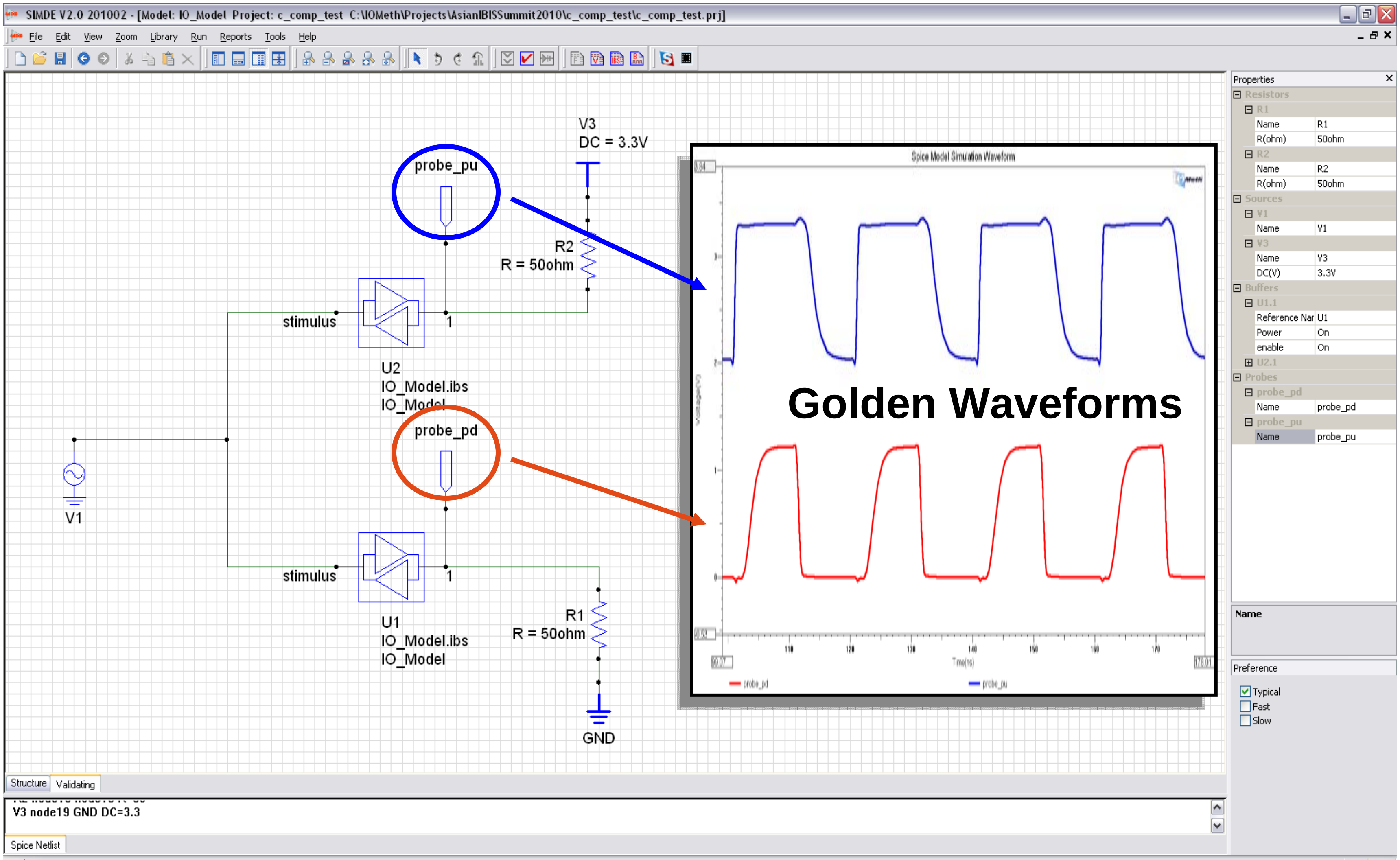
Copyright © 2006-2010
IO Methodology Inc.

Extracted C_comp values for different Pad DC settings @579MHz



Copyright © 2006-2010
IO Methodology Inc.

Test Topologies



Copyright © 2006-2010
IO Methodology Inc.

Simulation result accuracy fact sheet for different setting C_comp values

Frequency: 579MHz		probe_pd		probe_pu	
Input (V)	**Pad DC (V)**	**DAI (%)**	**DPI (%)**	**DAI (%)**	**DPI (%)**
3.3	1.65	0.29	4.02	0.57	24.18
3.3	2.7	0.3	4.02	0.58	25.65
3.3	0.6	0.3	3.98	0.6	26.99
0	1.65	0.27	4	0.48	17.3
0	2.7	0.27	4.01	0.47	17.38
0	0.6	0.29	3.83	0.61	28.39

Using C_comp not C_comp_xxx

DAI – Differential Average Index, DPI – Differential Peak Index

Copyright © 2006-2010
IO Methodology Inc.

Conclusions

- C_comp (reference to global GND) may not be enough for all the cases
  - C_comp_*** are more accurate representing die capacitance for the buffer
  - Bad news is that not all simulators handles or correctly handles C_comp_***
- Be careful to pick C_comp and C_comp_*** values depending on your applications.
  - Medium supply voltage is practical for extractions
- Depends on the application, sometimes, with only C_comp could represent die capacitance accurately in the simulations
  - Termination to GND cases
- C_comp_*** could help correctly handling Driving / Receiving
  - Need a test

Copyright © 2006-2010
IO Methodology Inc.

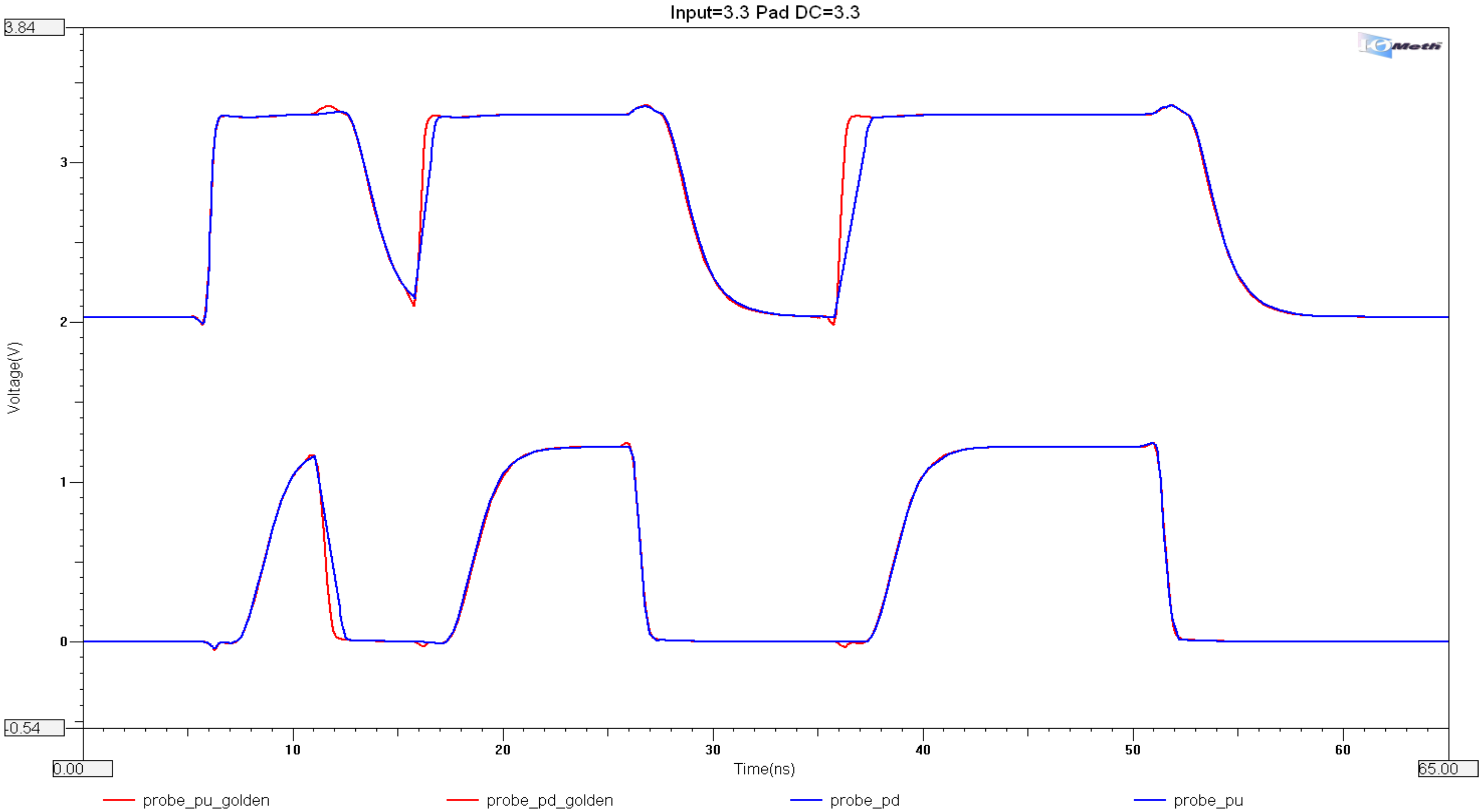
Modeling Specialist

IOMeth™

Back-up Slides

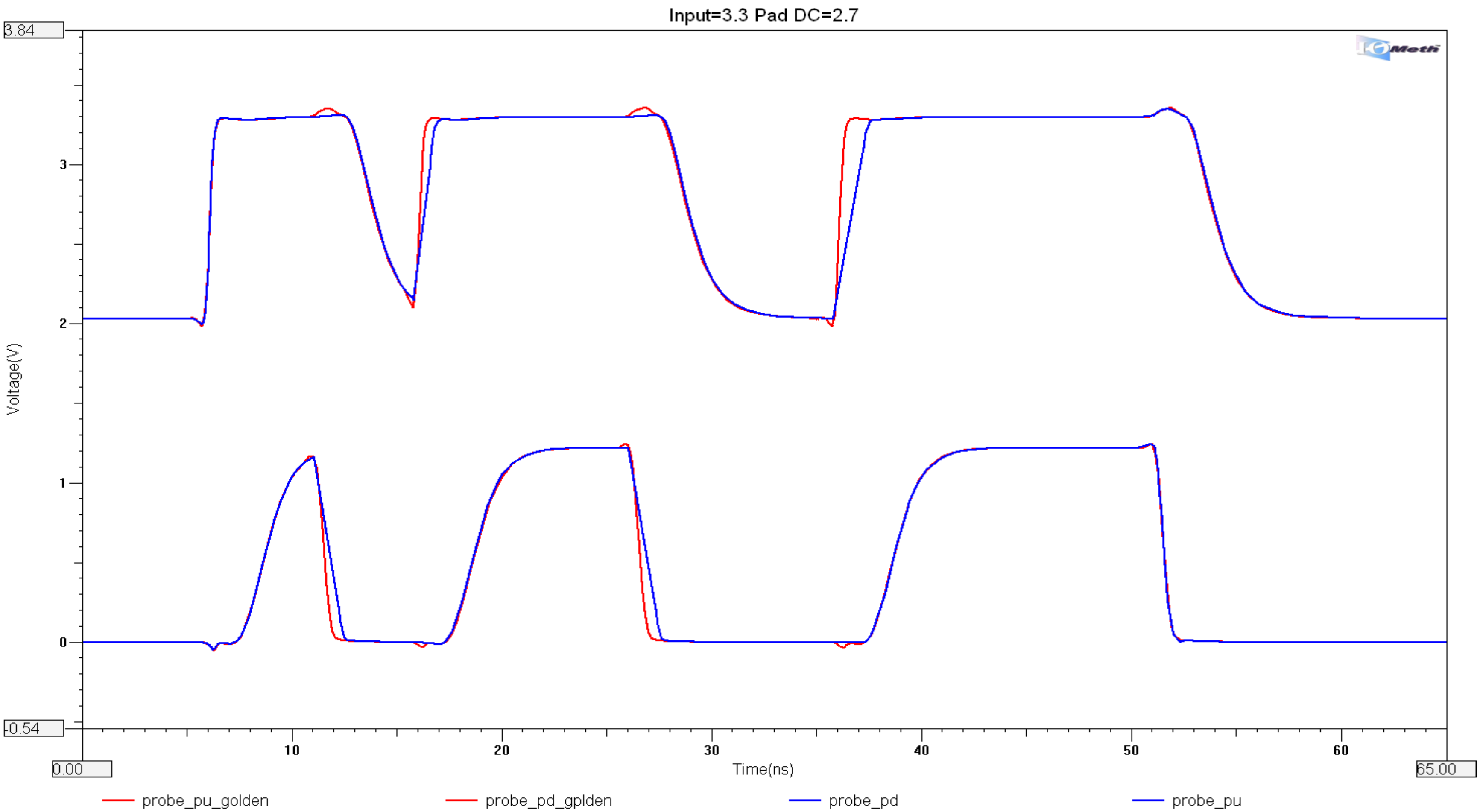
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.62%(DA = 0.01), DPI = 30.25%(DP = 0.39)
probe_pu: DAI = 1.50%(DA = 0.02), DPI = 54.23%(DP = 0.75)



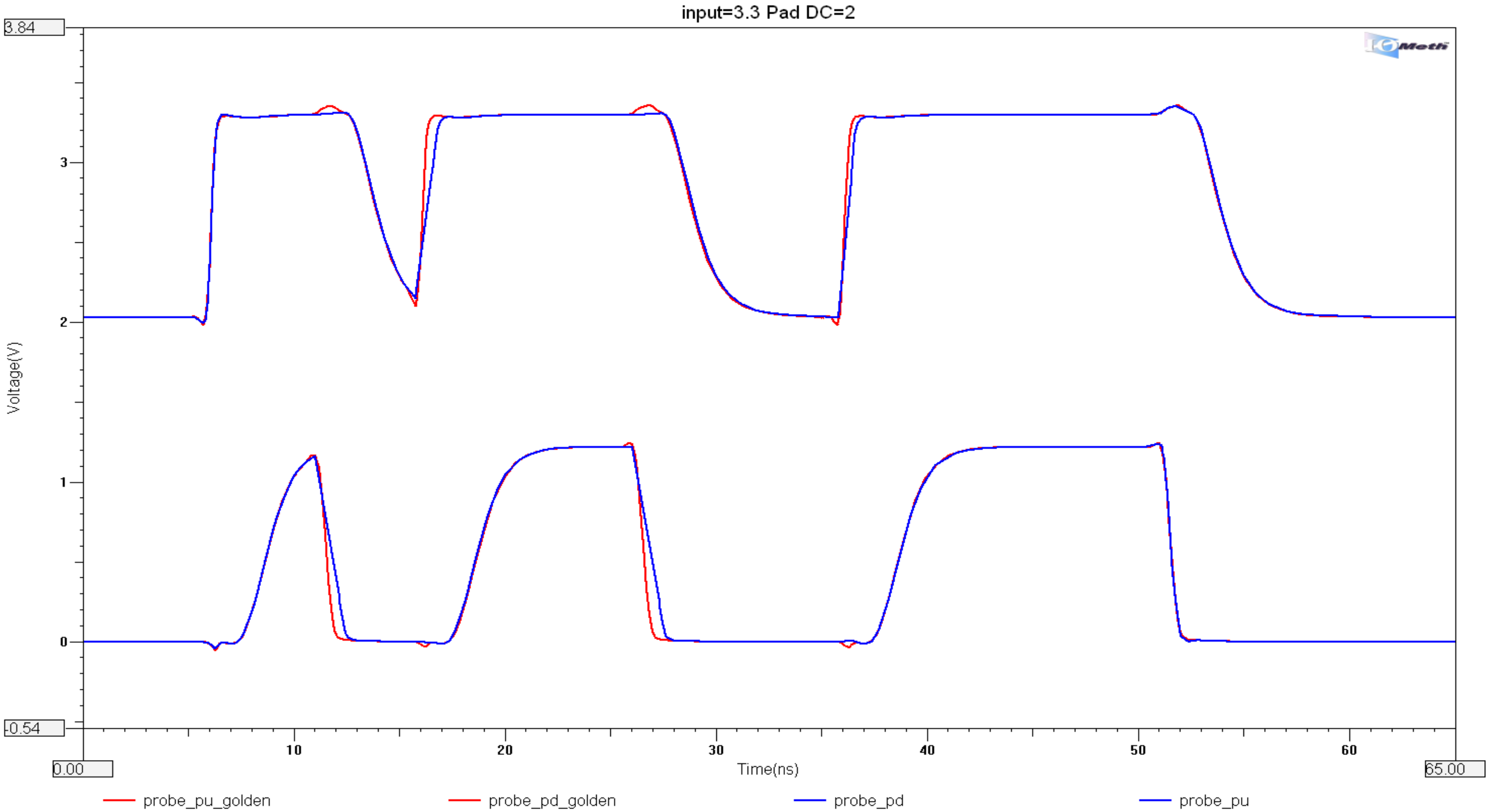
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.06%(DA = 0.01), DPI = 34.43%(DP = 0.45)
probe_pu: DAI = 1.59%(DA = 0.02), DPI = 54.38%(DP = 0.75)



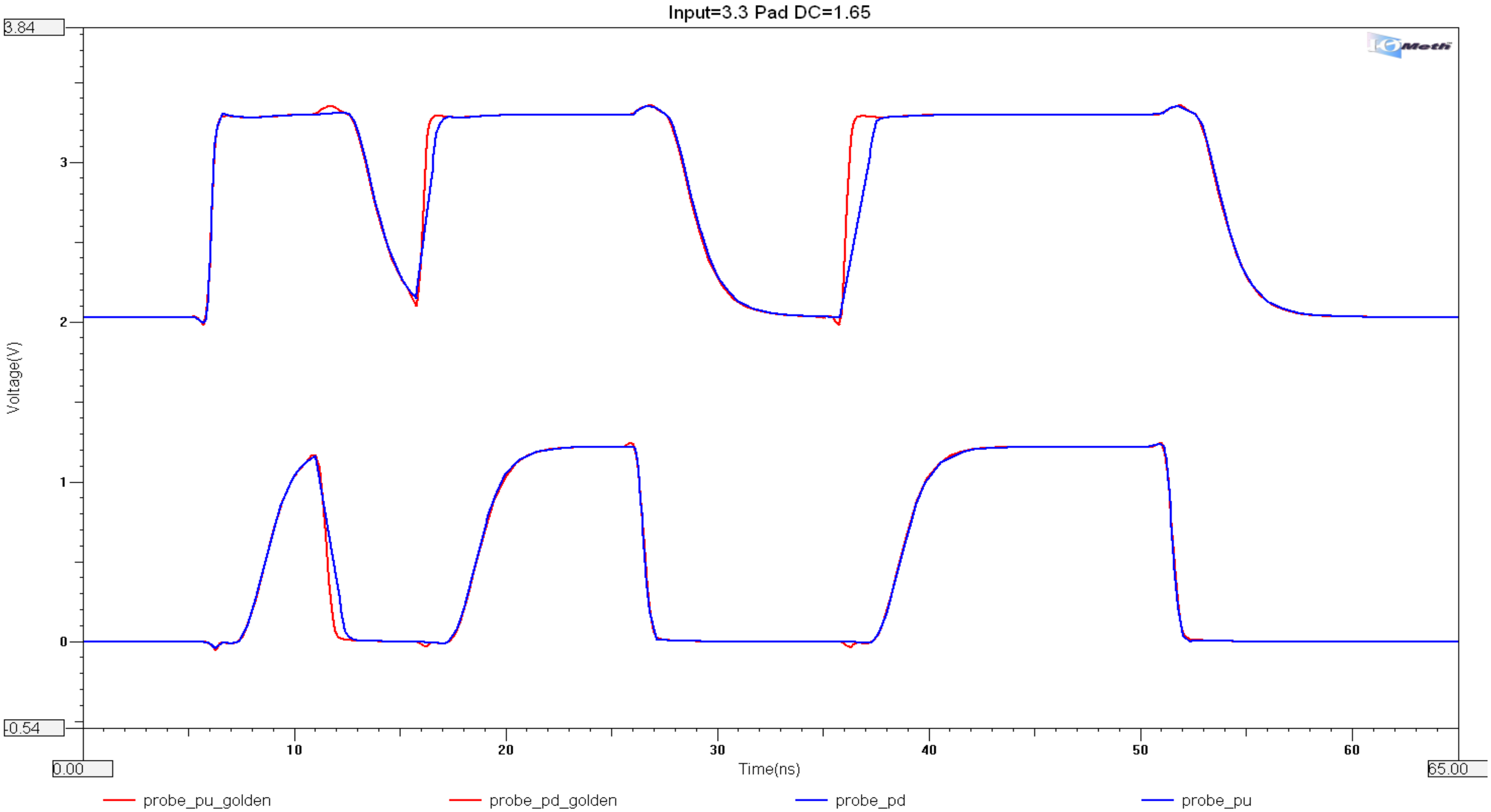
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.09%(DA = 0.01), DPI = 35.51%(DP = 0.46)
probe_pu: DAI = 1.00%(DA = 0.01), DPI = 35.71%(DP = 0.49)



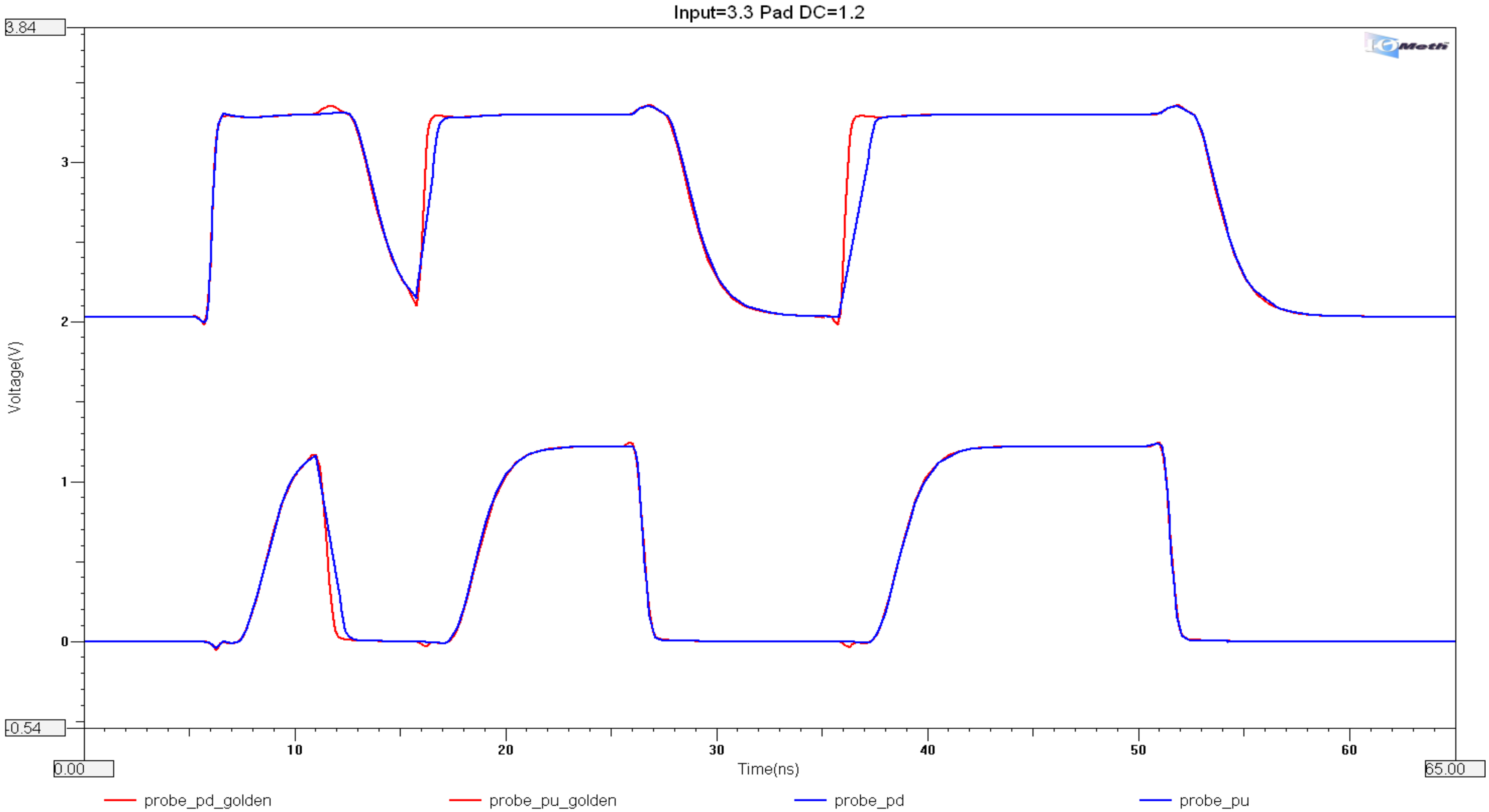
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.62%(DA = 0.01), DPI = 29.88%(DP = 0.39)
probe_pu: DAI = 1.55%(DA = 0.02), DPI = 55.03%(DP = 0.76)



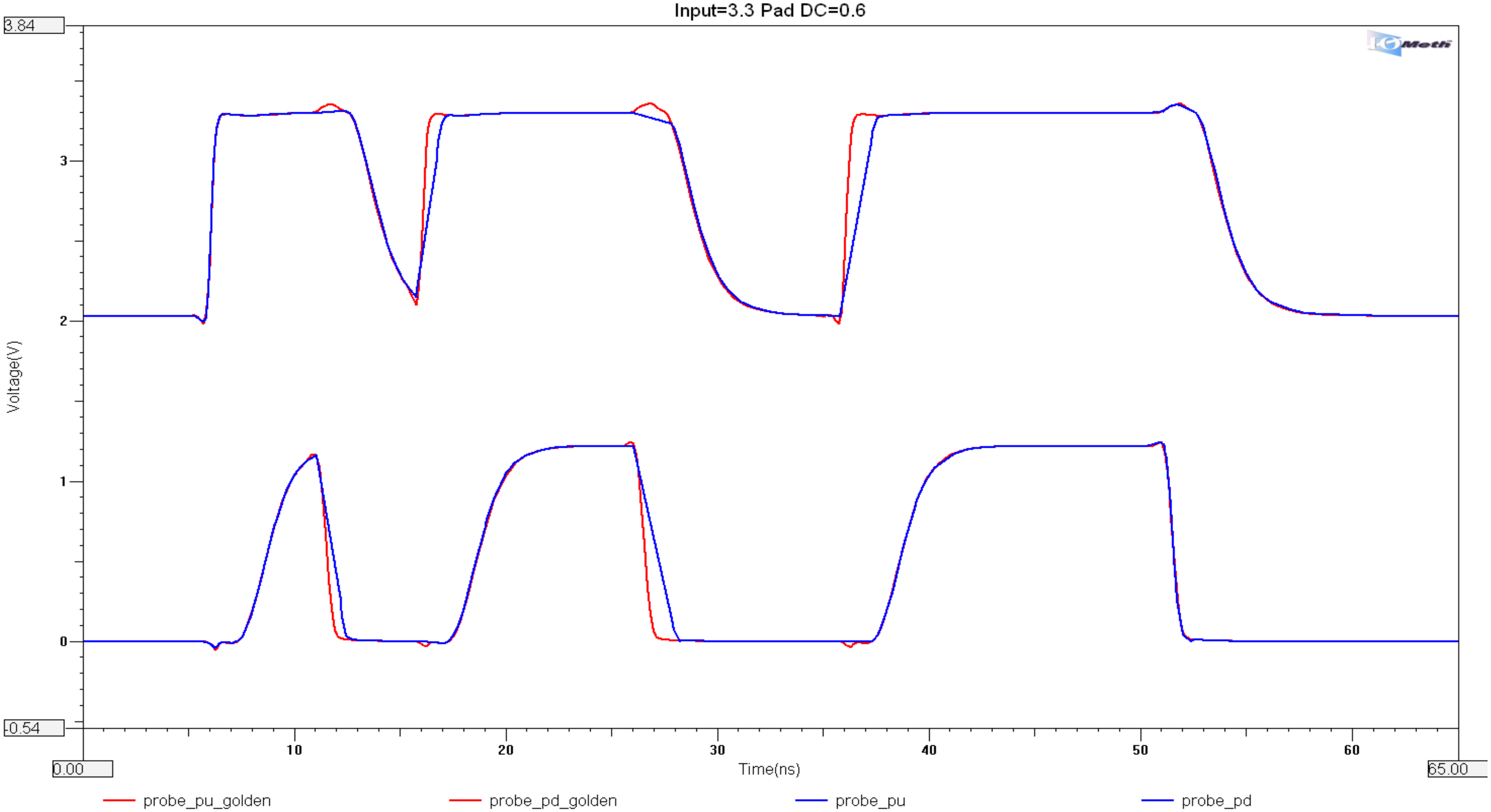
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.60%(DA = 0.01), DPI = 30.06%(DP = 0.39)
probe_pu: DAI = 1.60%(DA = 0.02), DPI = 55.03%(DP = 0.76)



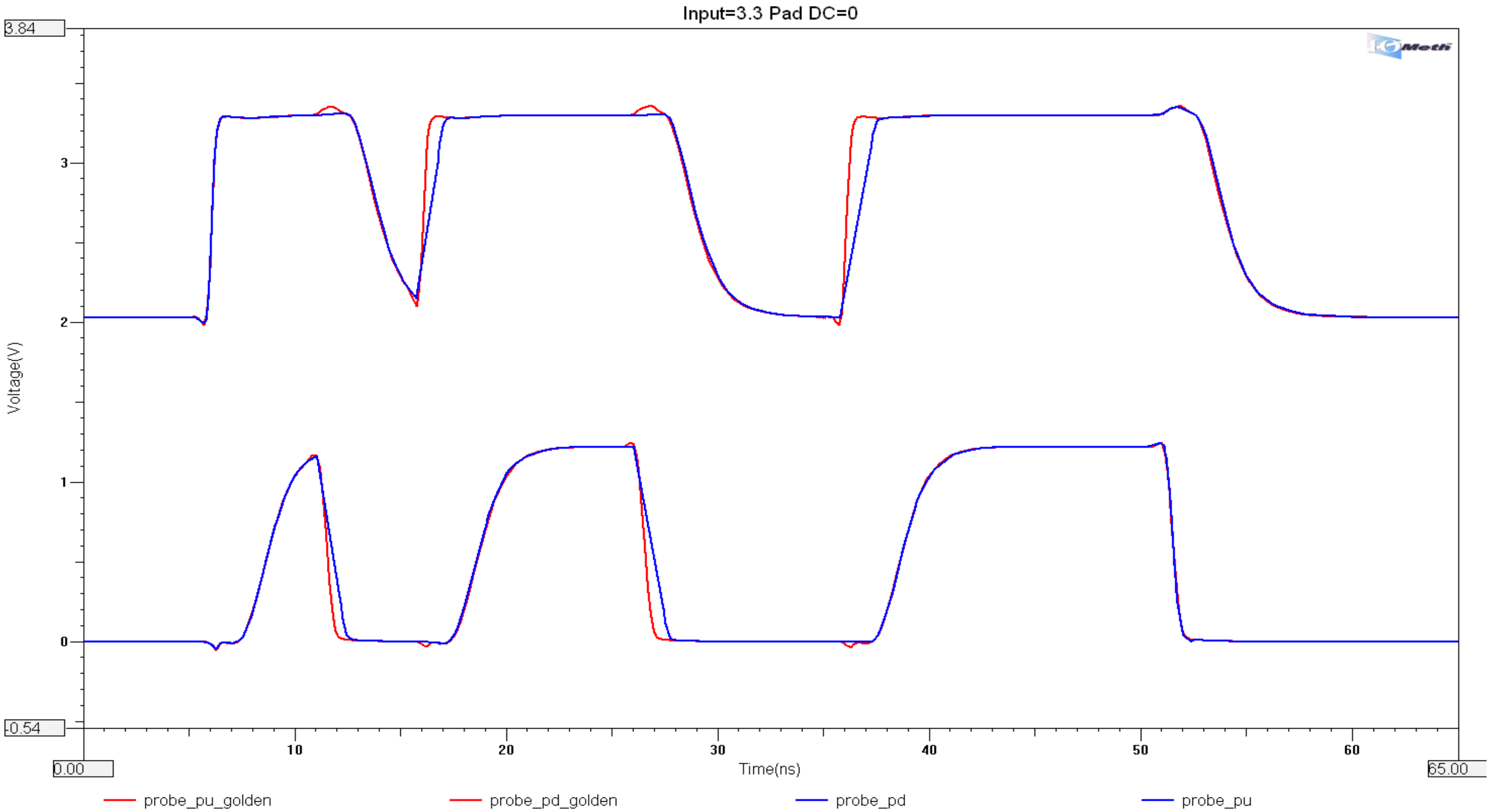
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.43%(DA = 0.02), DPI = 46.55%(DP = 0.60)
probe_pu: DAI = 1.77%(DA = 0.02), DPI = 54.50%(DP = 0.75)



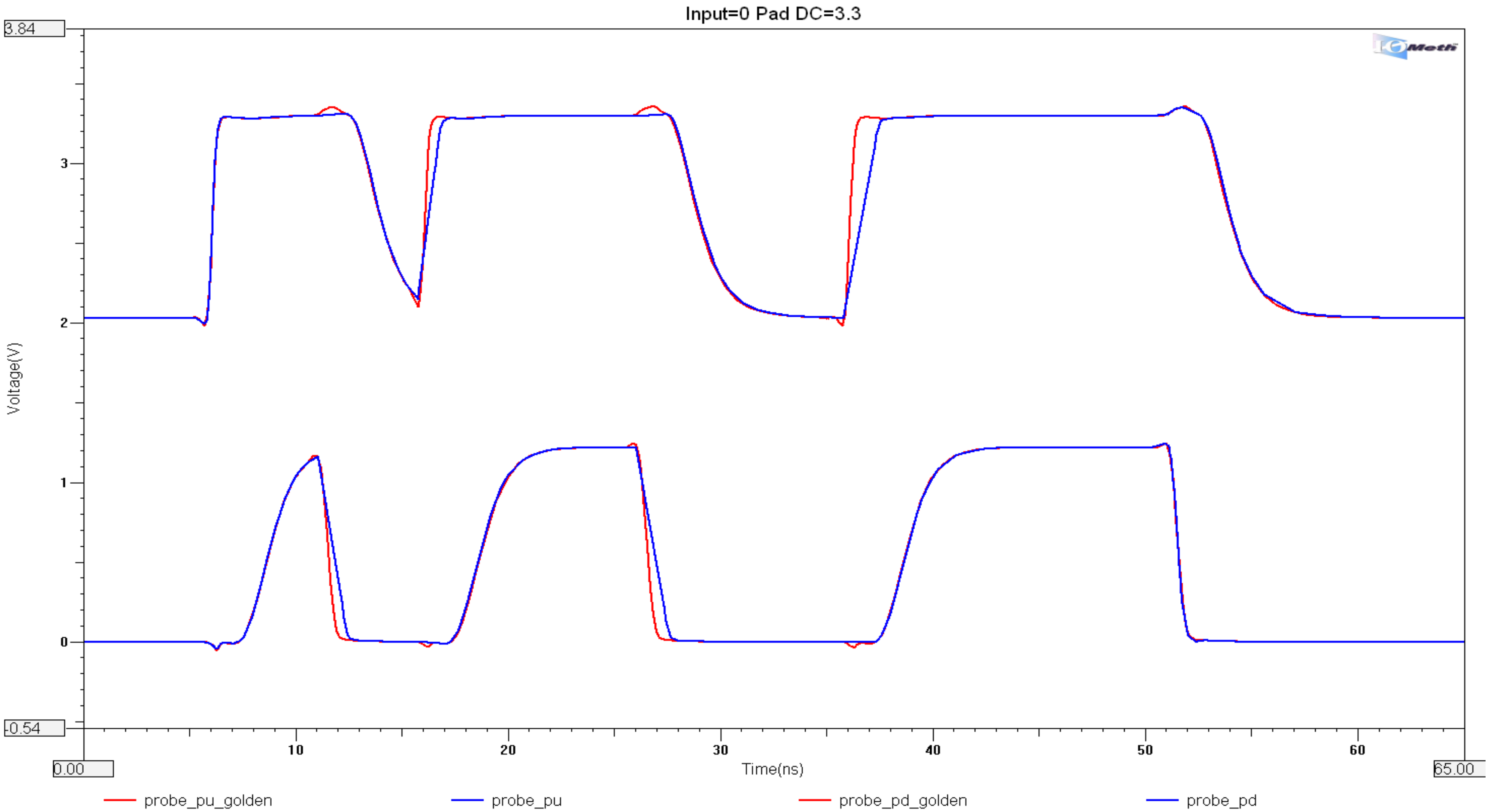
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.14%(DA = 0.01), DPI = 37.46%(DP = 0.48)
probe_pu: DAI = 1.74%(DA = 0.02), DPI = 54.52%(DP = 0.75)



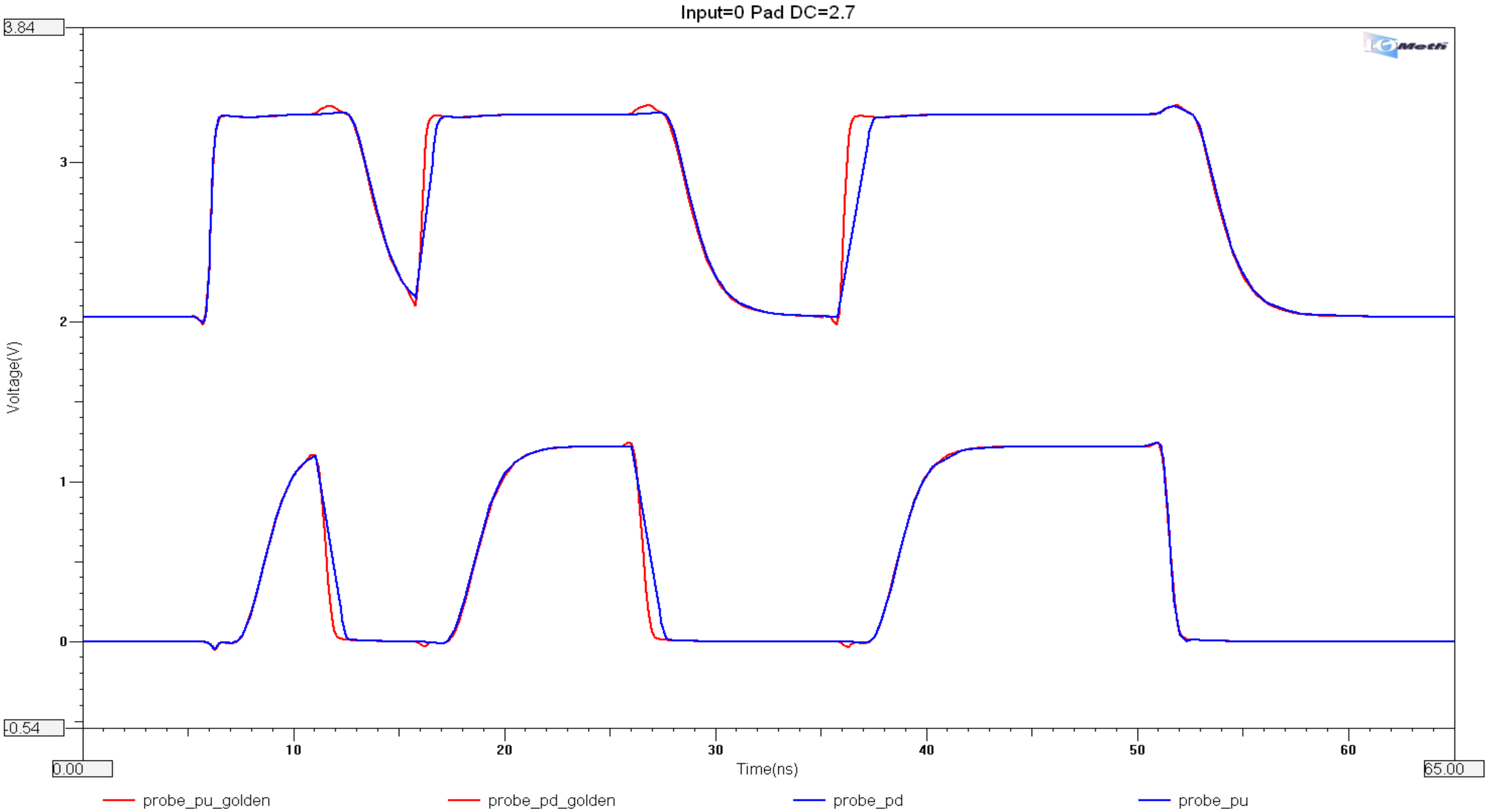
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.08%(DA = 0.01), DPI = 35.26%(DP = 0.46)
probe_pu: DAI = 1.62%(DA = 0.02), DPI = 54.66%(DP = 0.75)



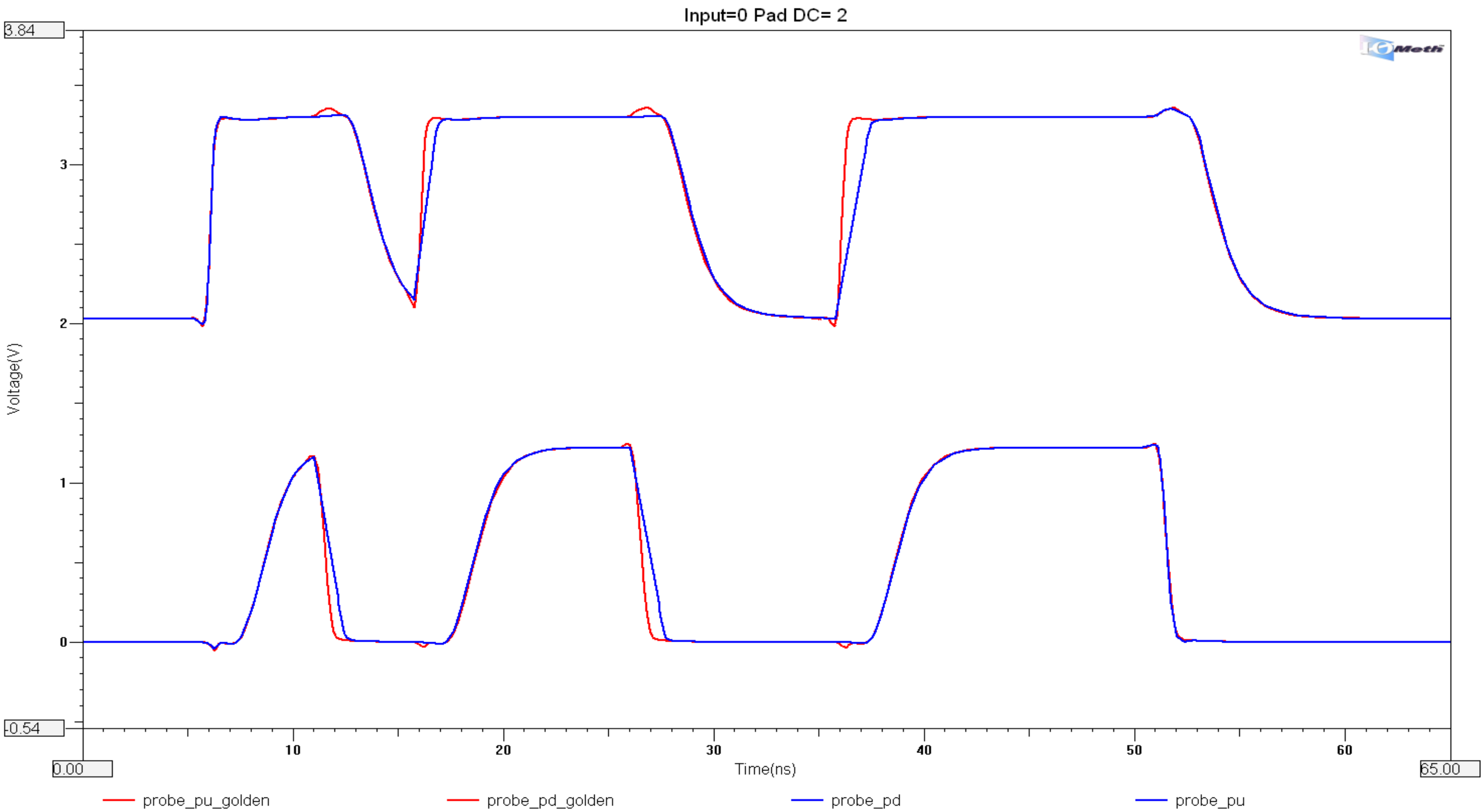
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.08%(DA = 0.01), DPI = 34.53%(DP = 0.45)
probe_pu: DAI = 1.55%(DA = 0.02), DPI = 53.37%(DP = 0.73)



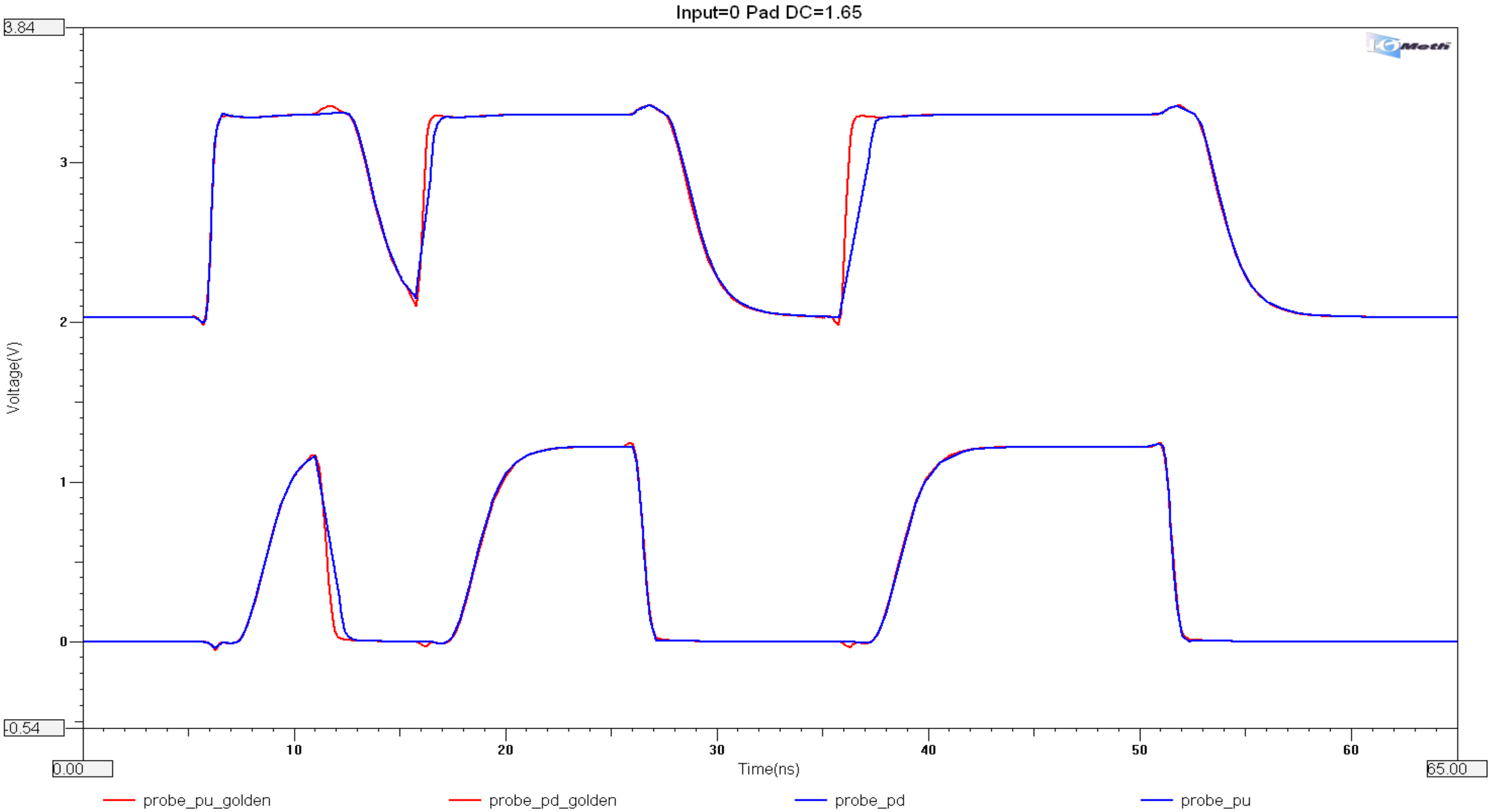
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.15%(DA = 0.01), DPI = 37.64%(DP = 0.49)
probe_pu: DAI = 1.62%(DA = 0.02), DPI = 54.44%(DP = 0.75)



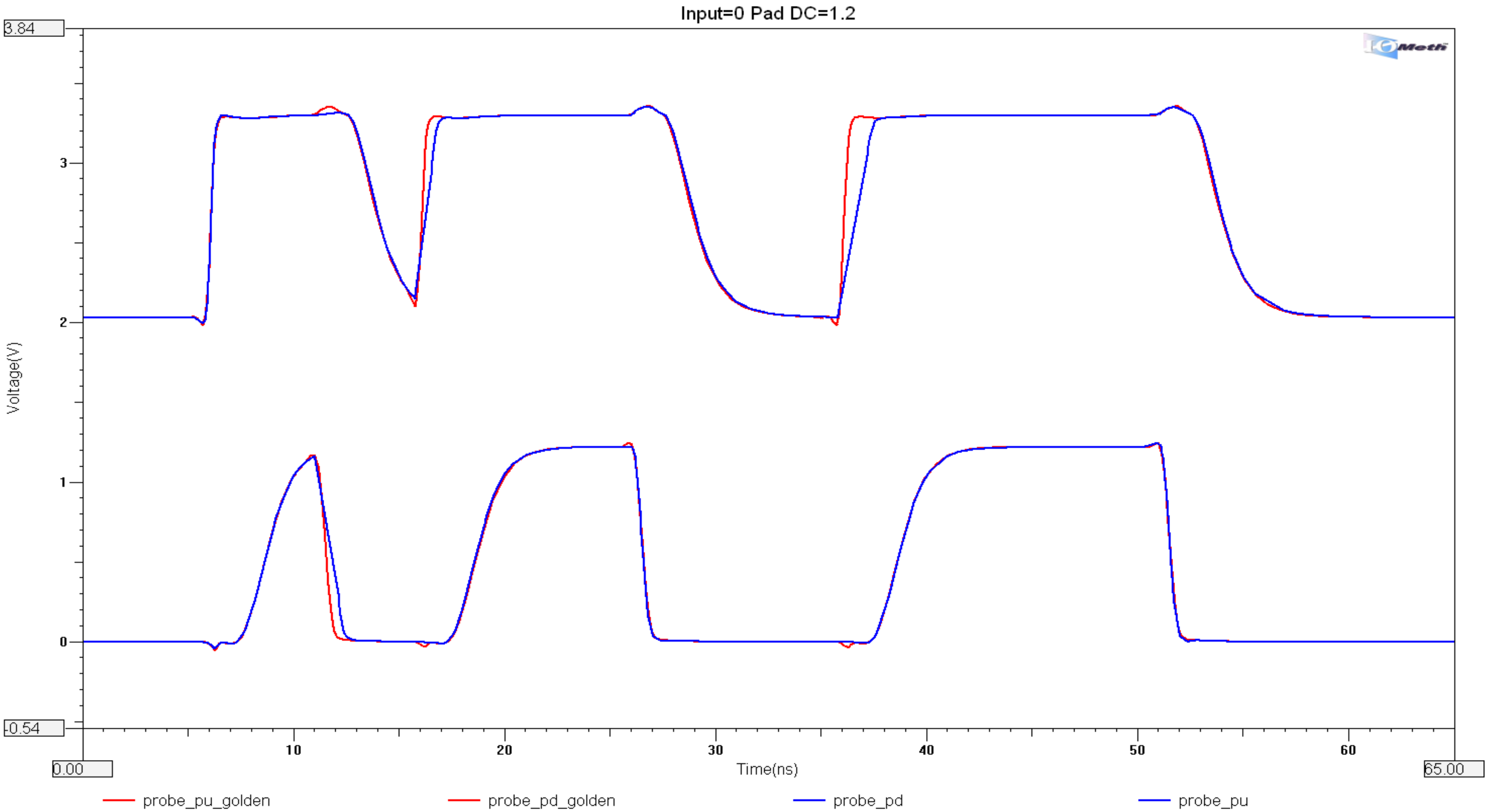
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.62%(DA = 0.01), DPI = 29.88%(DP = 0.39)
probe_pu: DAI = 1.51%(DA = 0.02), DPI = 54.96%(DP = 0.76)



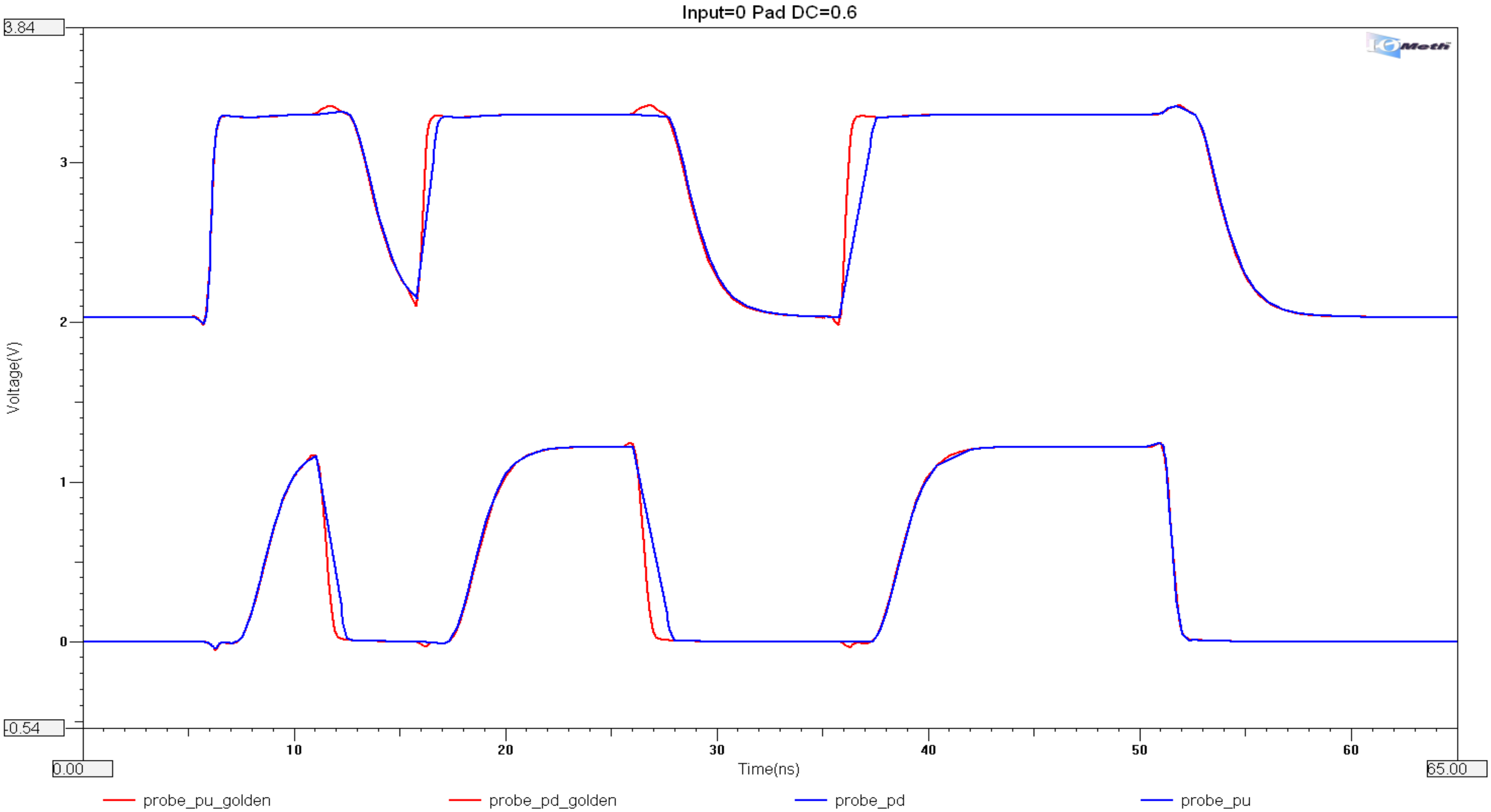
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.59%(DA = 0.01), DPI = 29.49%(DP = 0.38)
probe_pu: DAI = 1.54%(DA = 0.02), DPI = 54.71%(DP = 0.75)



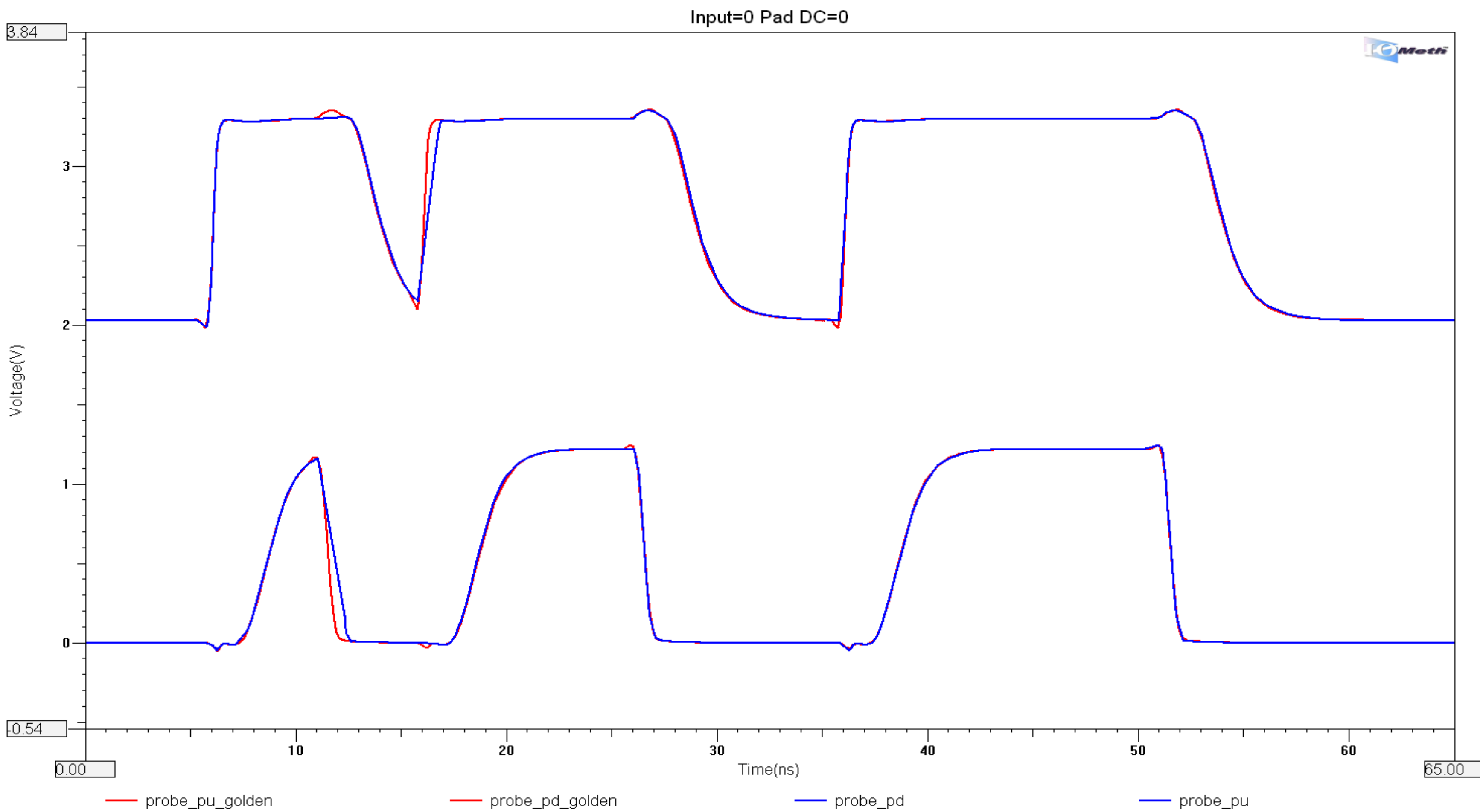
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 1.30%(DA = 0.02), DPI = 42.09%(DP = 0.54)
probe_pu: DAI = 1.57%(DA = 0.02), DPI = 54.27%(DP = 0.75)



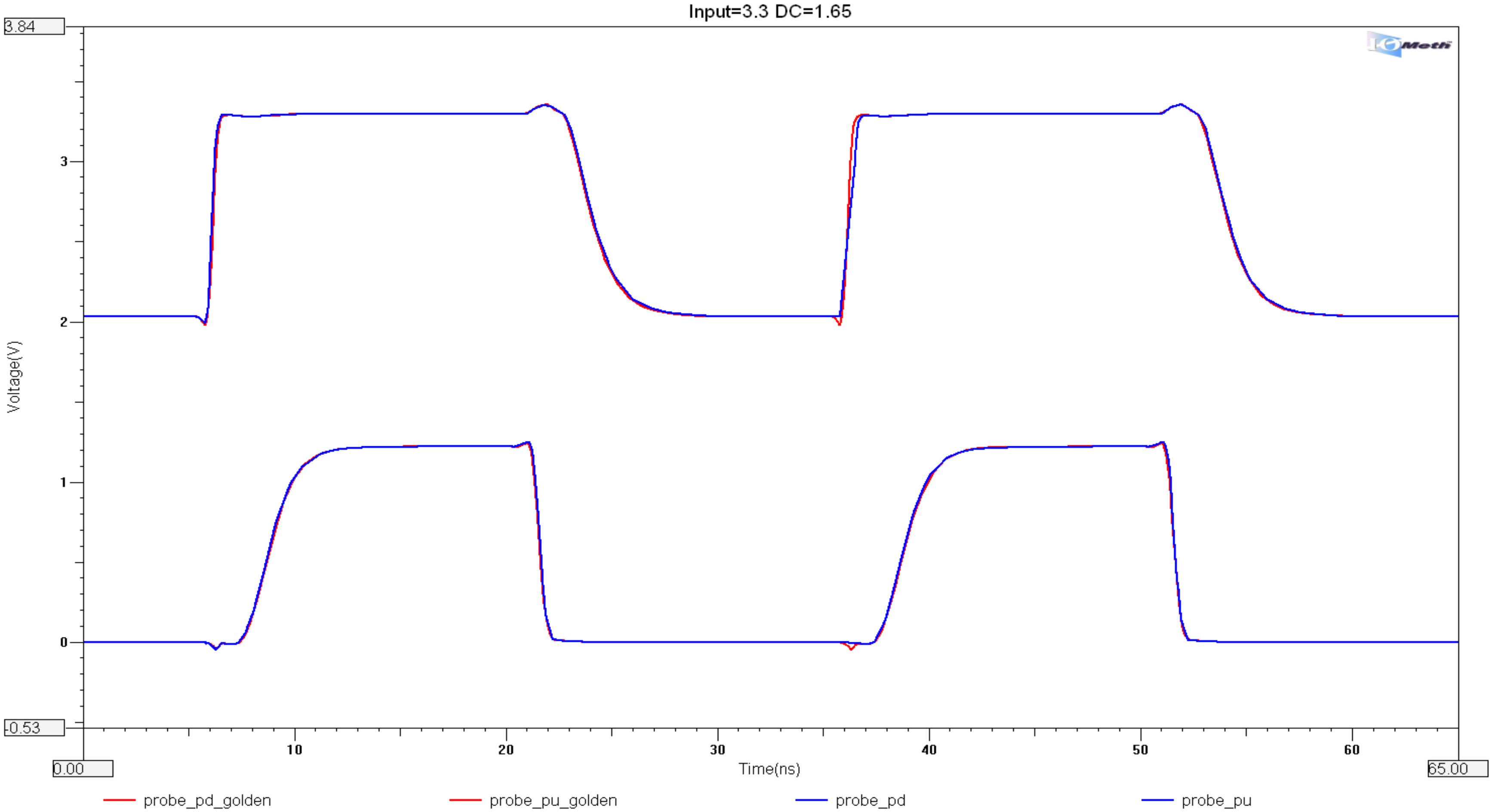
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.61%(DA = 0.01), DPI = 31.08%(DP = 0.40)
probe_pu: DAI = 0.74%(DA = 0.01), DPI = 34.45%(DP = 0.47)



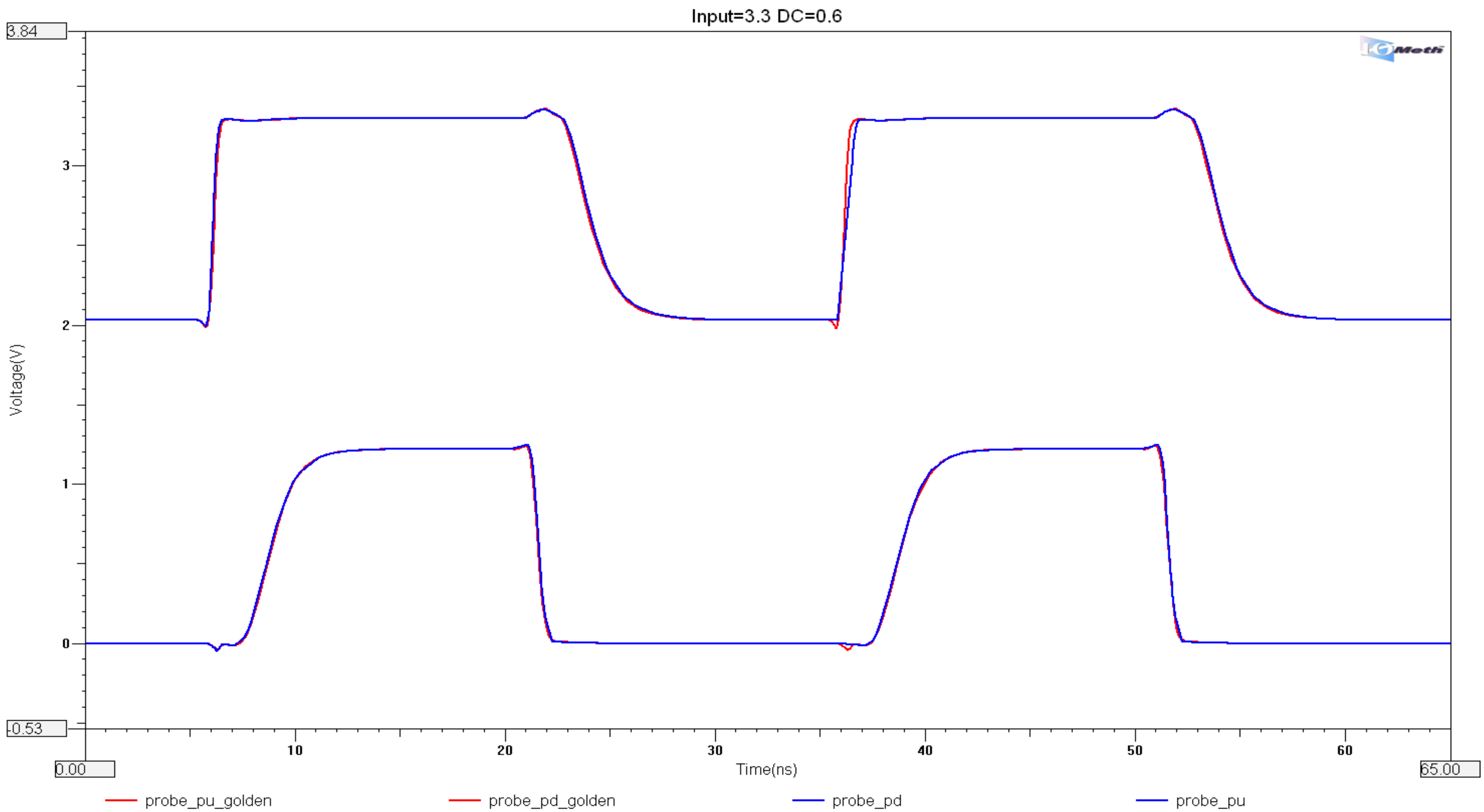
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.29%(DA = 0.00), DPI = 4.02%(DP = 0.05)
probe_pu: DAI = 0.57%(DA = 0.01), DPI = 24.18%(DP = 0.33)



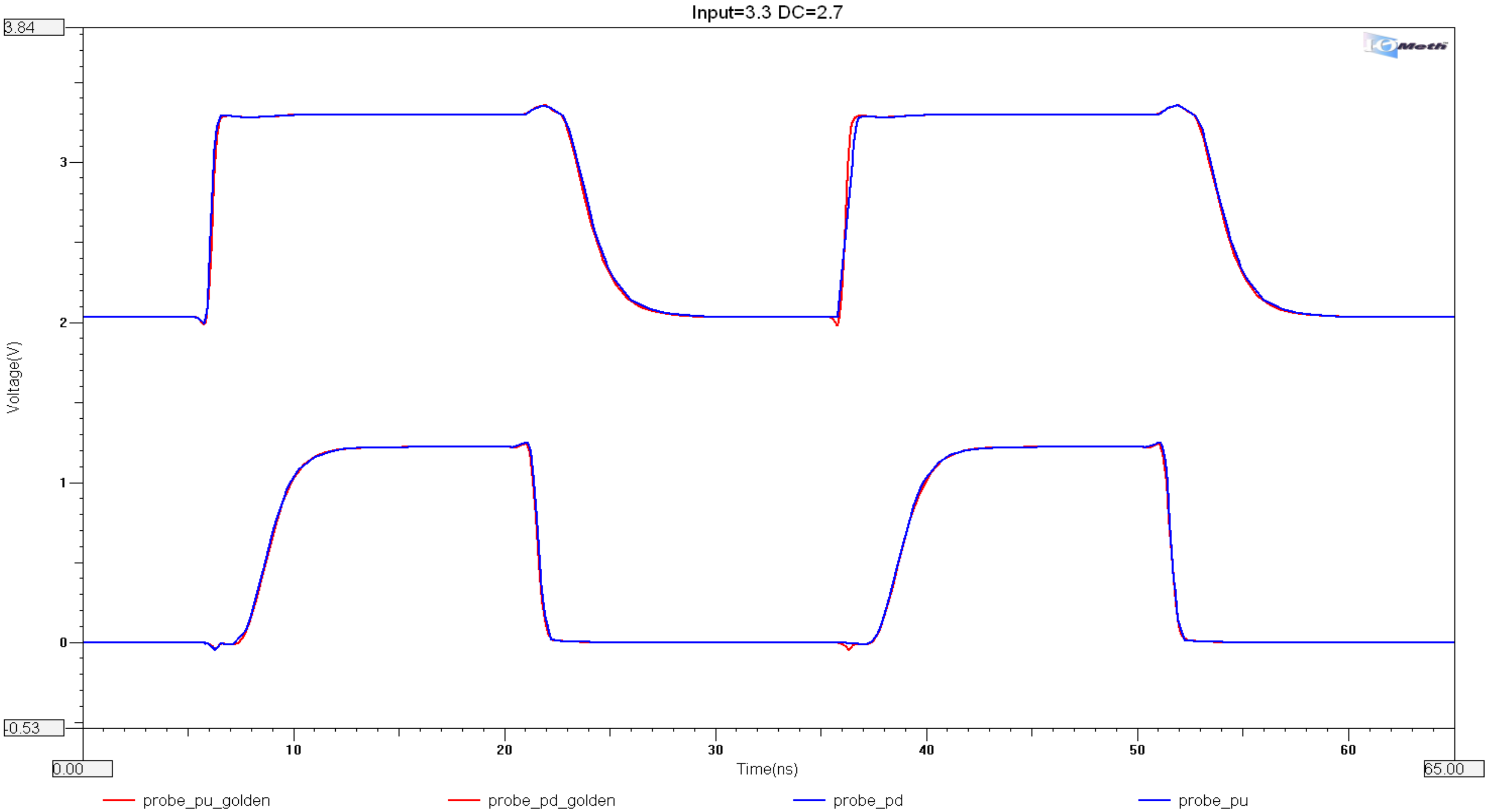
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.30%(DA = 0.00), DPI = 3.98%(DP = 0.05)
probe_pu: DAI = 0.60%(DA = 0.01), DPI = 26.99%(DP = 0.37)



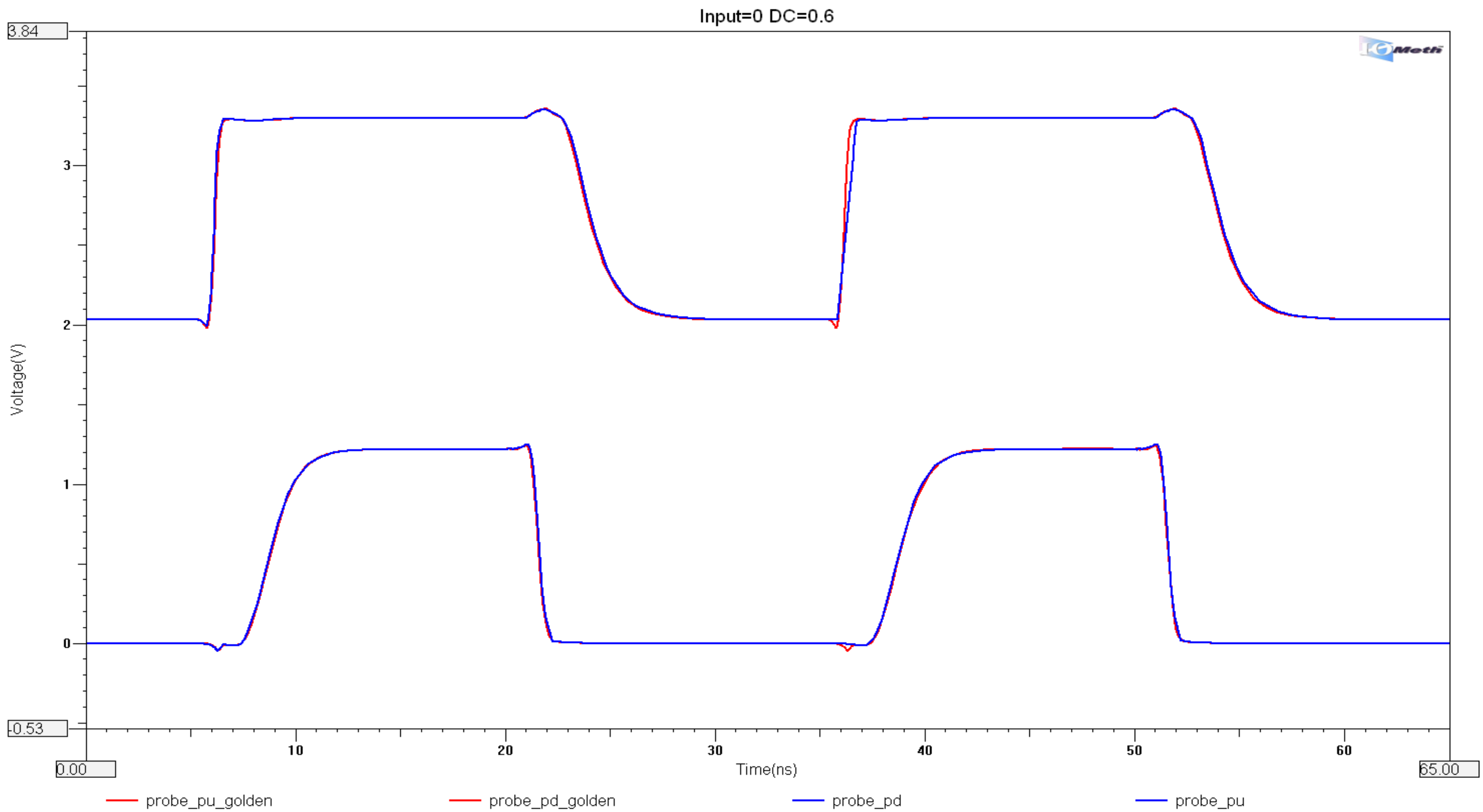
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.30%(DA = 0.00), DPI = 4.02%(DP = 0.05)
probe_pu: DAI = 0.58%(DA = 0.01), DPI = 25.65%(DP = 0.35)



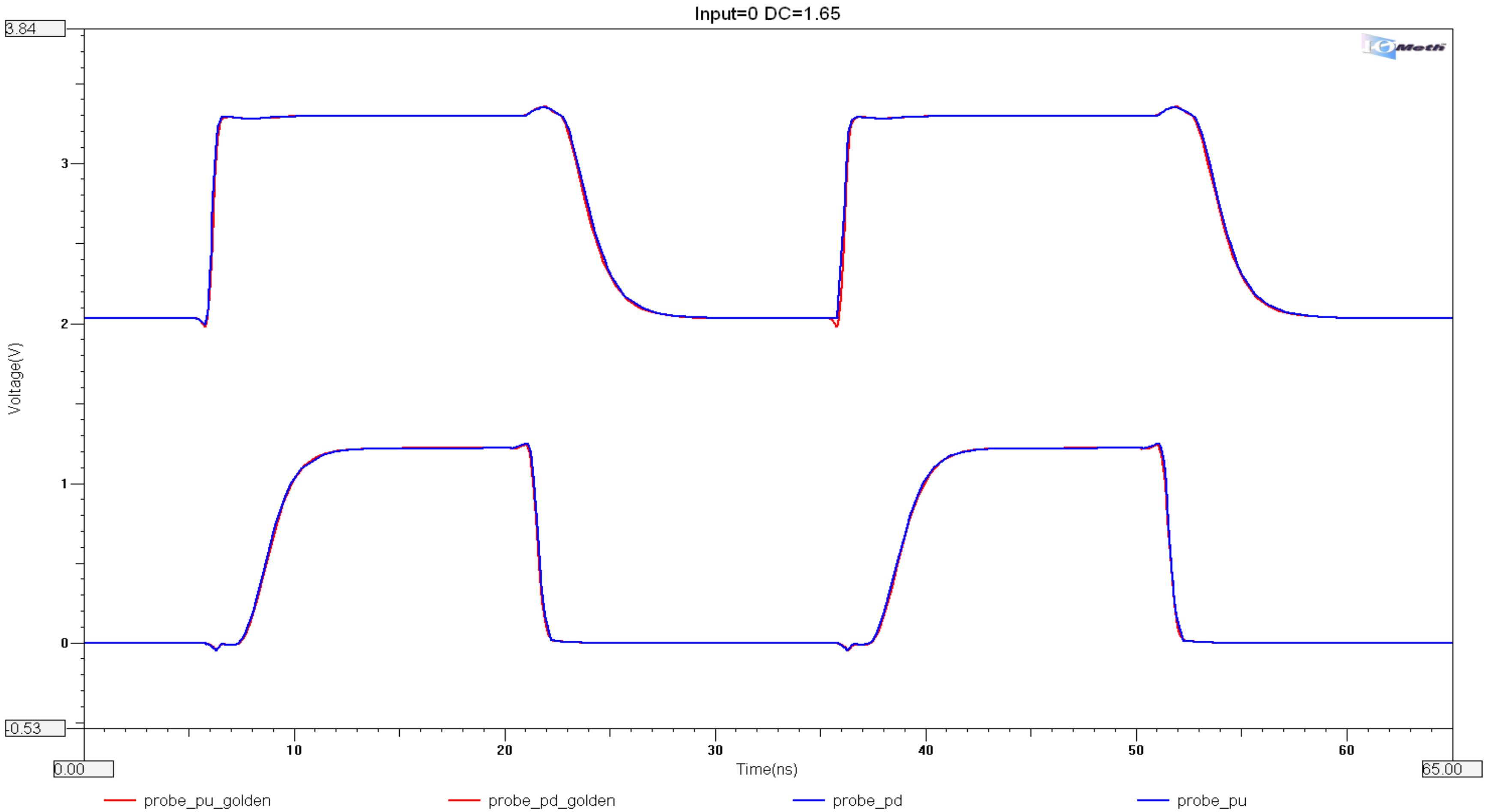
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.29%(DA = 0.00), DPI = 3.83%(DP = 0.05)
probe_pu: DAI = 0.61%(DA = 0.01), DPI = 28.39%(DP = 0.39)



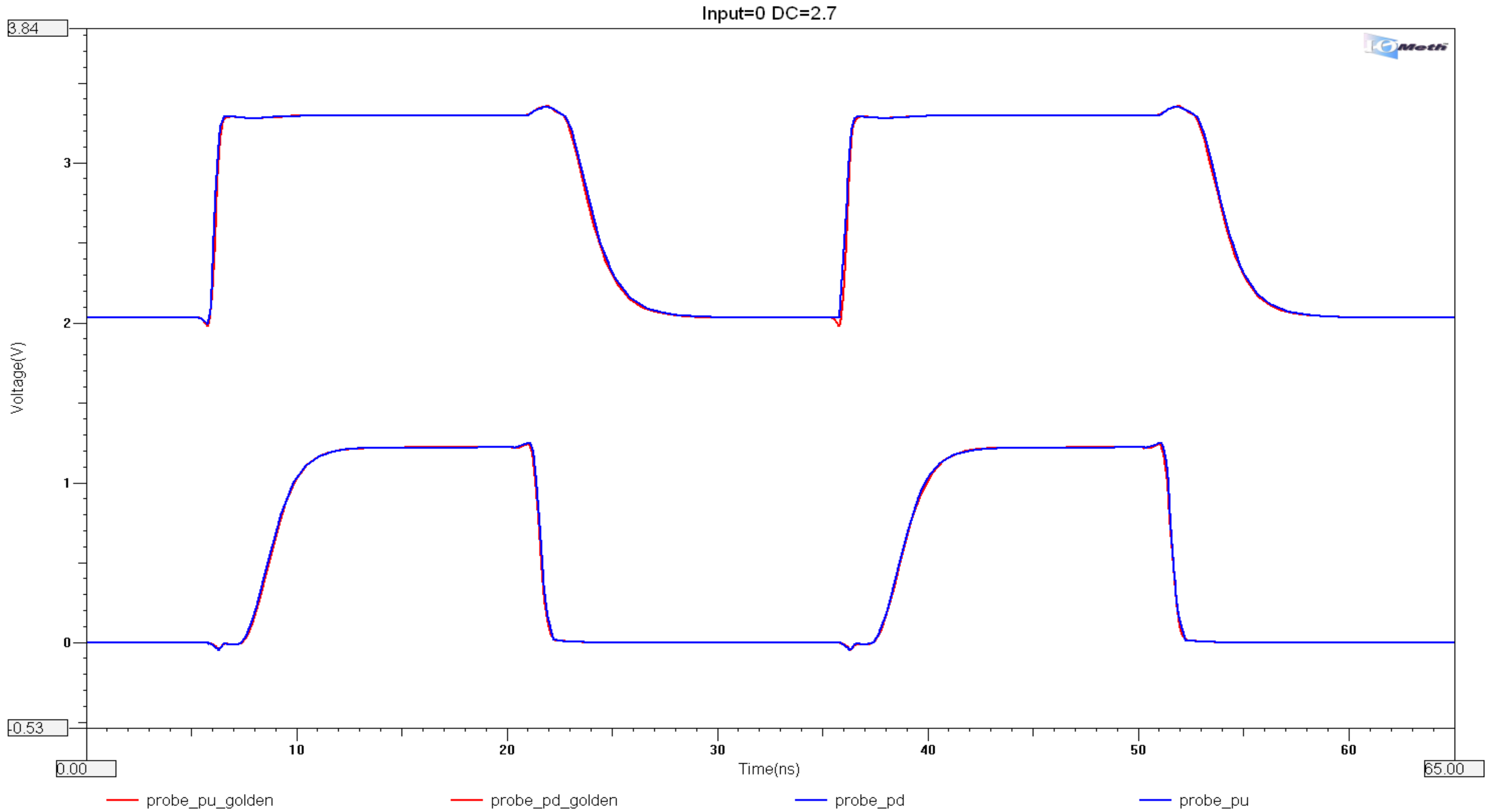
Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.27%(DA = 0.00), DPI = 4.00%(DP = 0.05)
probe_pu: DAI = 0.48%(DA = 0.01), DPI = 17.30%(DP = 0.24)



Copyright © 2006-2010
IO Methodology Inc.

probe_pd: DAI = 0.27%(DA = 0.00), DPI = 4.01%(DP = 0.05)
probe_pu: DAI = 0.47%(DA = 0.01), DPI = 17.38%(DP = 0.24)



Copyright © 2006-2010
IO Methodology Inc.