Nokia Siemens
Networks

Experiences with driver schedules

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DATE , Nice , France

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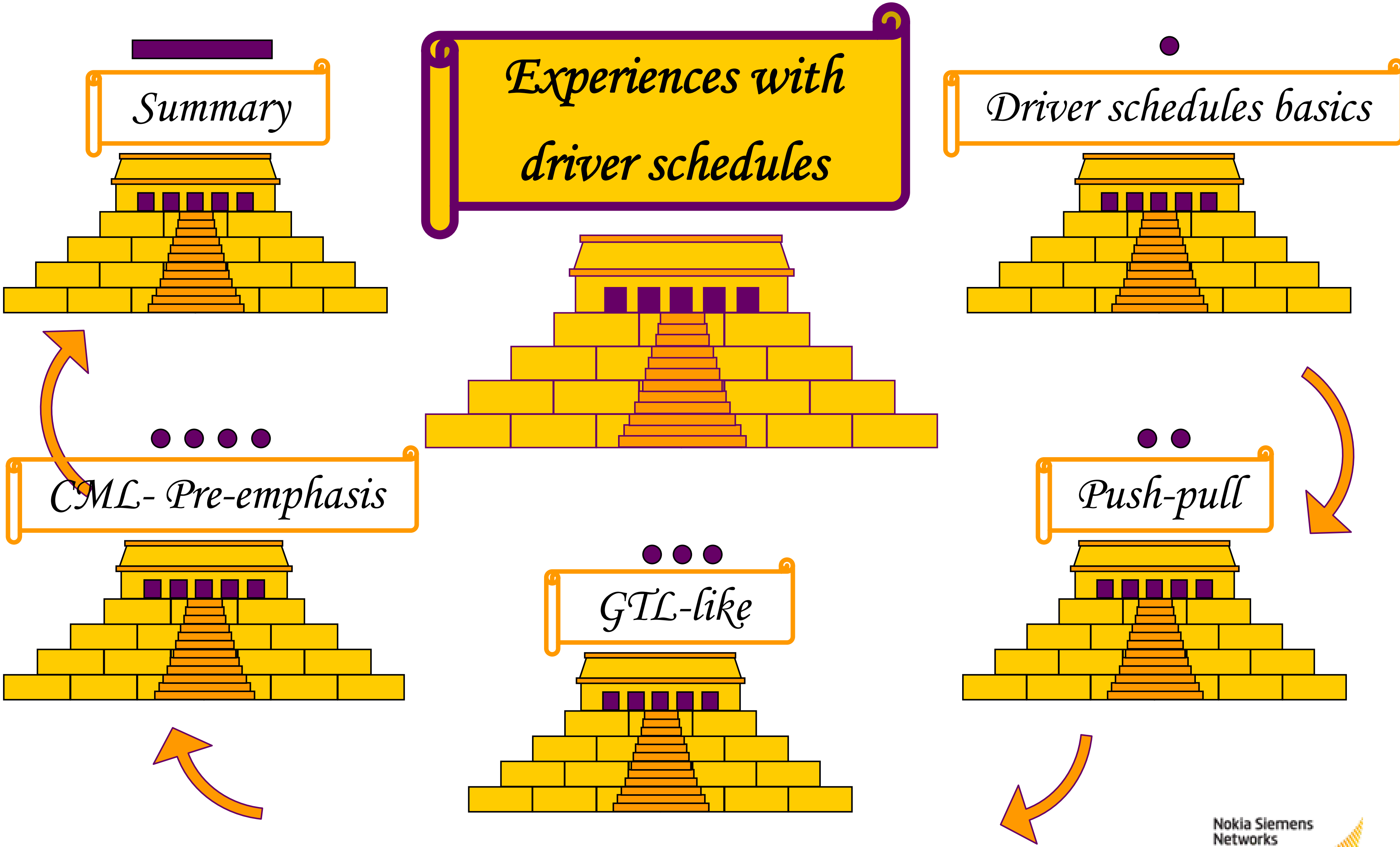
Agenda



Experiences with driver schedules

●
Driver schedules basics

● ●
Push-pull

● ● ●
GTL-like

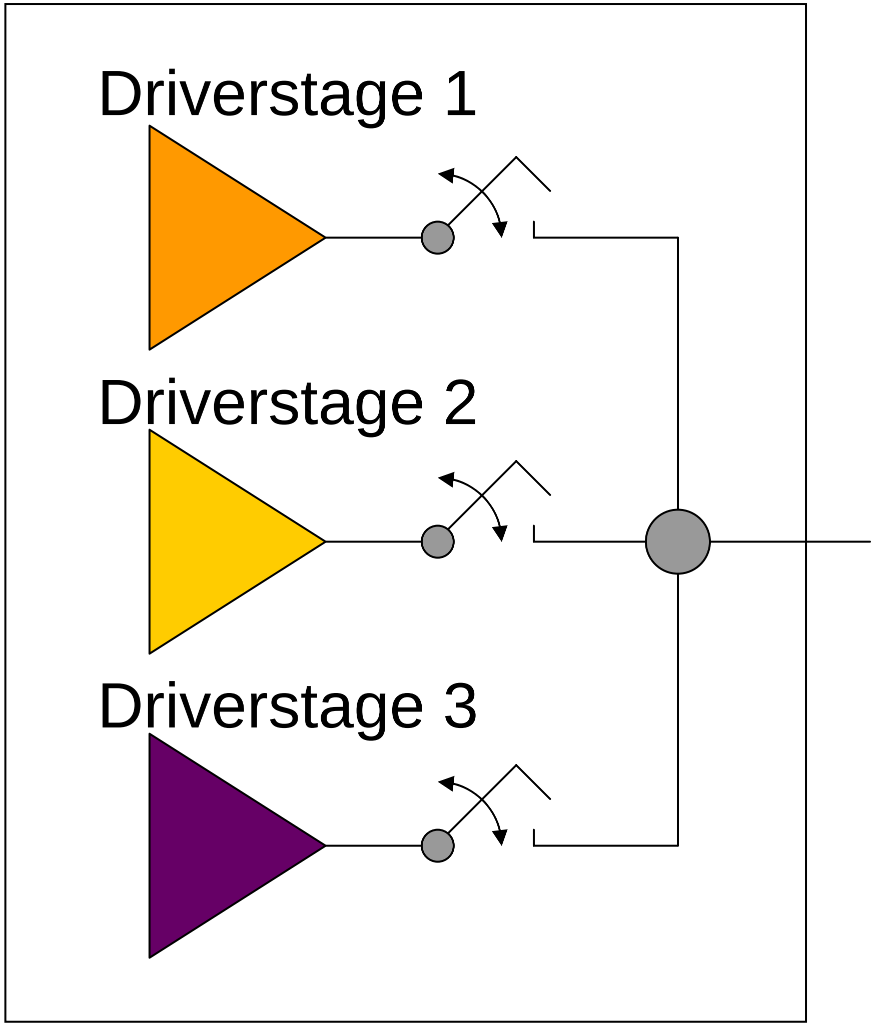
● ● ● ●
CML- Pre-emphasis

▬
Summary

Driver schedules basics

Driver schedule basics…

Multistage driver



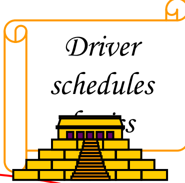
OUTPUT

A Multistage driver consists of several driverstages, which are switching at different times

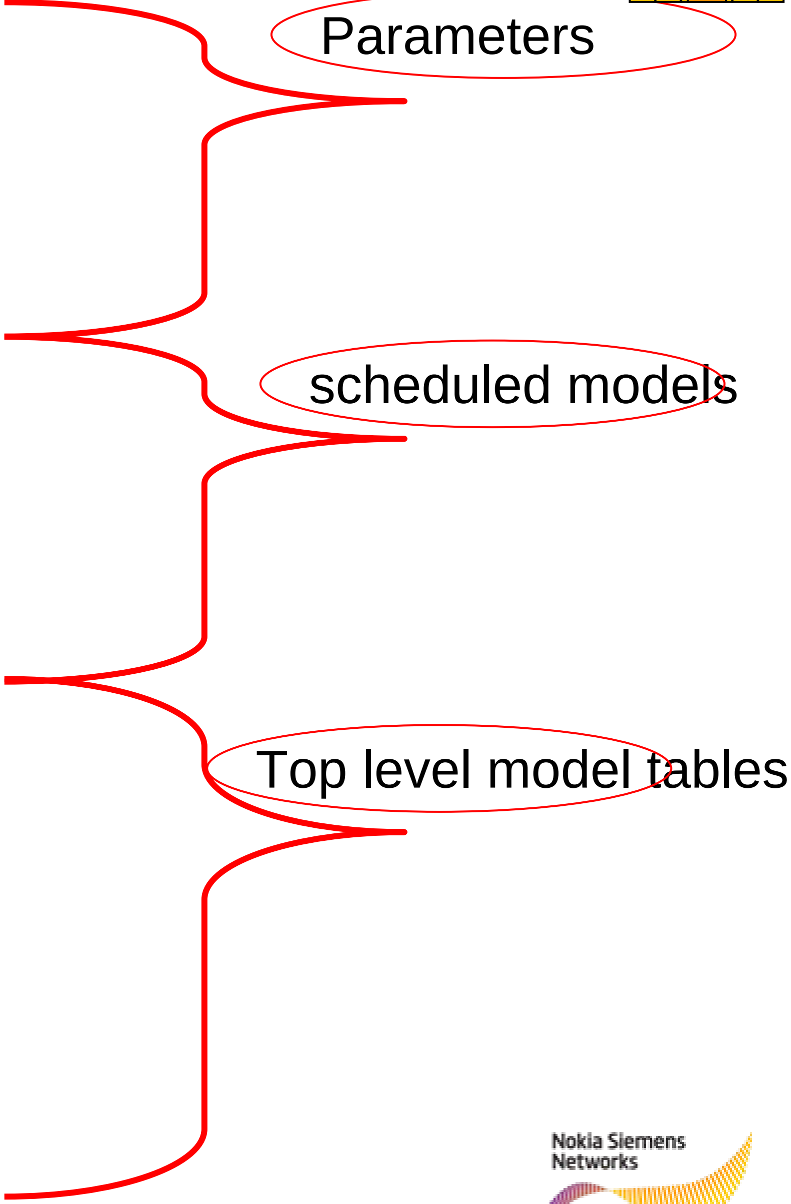
Or different voltage levels

Or ….

parts of IBIS Multistage driver model



```
[Model]       3-Driver-schedule
Model_type    I/O
Vinl = 0.68V
Vinh = 0.88V
C_comp                  1.5pF      1.0pF        2.0pF
[Voltage Range]         3.30V      3.1350V      3.4650V
[Driver Schedule]
|Model_name  Rise_on_dly  Rise_off_dly  Fall_on_dly  Fall_off_dly
MODEL_1      0s           NA            0ns          NA
MODEL_2      0.5ns        NA            0ns          NA
MODEL_3      1.0ns        2.5ns         NA           NA
[GND Clamp]
[POWER Clamp]
[Pulldown]
[Pullup]
3.00     0.00     0.00   0.00
[Ramp]
dV/dt_r      1.00V/1.8ns     0.9V/2.50ns     1.1V/1.0ns
dV/dt_f      1.3V/1.5ns      1.1V/2.0ns      1.4V/0.9ns
```



Parameters

scheduled models

Top level model tables

top level model

C_comp

[Voltage Range] 3.30V

[GND Clamp]

[POWER Clamp]

[Pulldown]

[Pullup]

[Ramp]

dV/dt_r 1.00V/1.8ns

dV/dt_f 1.3V/1.5ns

Top level model tables

For tools, which don’t understand the [Driver schedule] keyword, there is a description of the rough/approximate behavior of the output with normal IBIS keywords, (called top level model)

Driver schedules
basics

scheduled models

```
[Model]       3-Driver-schedule

Model_type    I/O

[Driver Schedule]
|Model_name  Rise_on_dly  Rise_off_dly  Fall_on_dly  Fall_off_dly
MODEL_1      0s           NA            0ns          NA
MODEL_2      0.5ns        NA            0ns          NA
MODEL_3      1.0ns        2.5ns         NA           NA
```

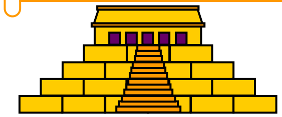
scheduled models

The Driver schedule contains the exact timing information about the time, when the different driverstages are used.

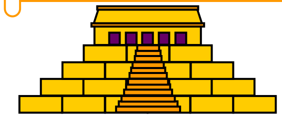
The switching behavior of each driverstage itself is described like that of a normal IBIS IO-model in a [Model] statement

scheduled models timing

Driver schedules basics



	rising edge (L->H)		falling edge (H->L)	
|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**1.0ns**	**2.5ns**	**0ns**	**NA**
	turn on pullup-structure	turn off pullup-structure	turn on pulldown-structure	turn off pulldown-structure
	turn off pulldown-structure	turn on pulldown-structure	turn off pullup-structure	turn on pullup-structure



example timing schedule

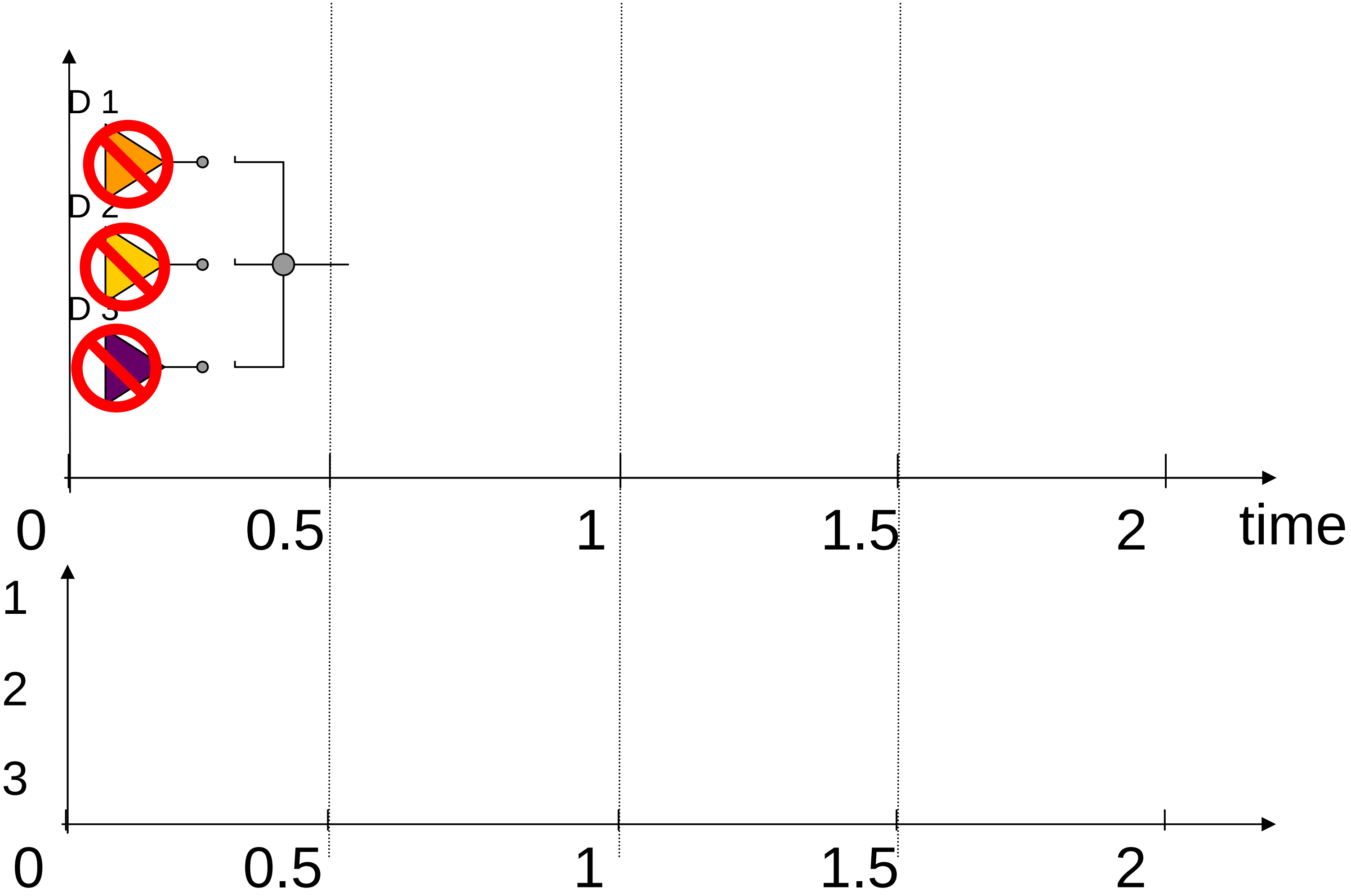
[Driver Schedule]

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	0.5ns	NA	0ns	NA
MODEL_2	1.0ns	NA	0ns	NA
MODEL_3	1.5ns	2.5ns	NA	NA

time schedule t=0

Driver schedules basics

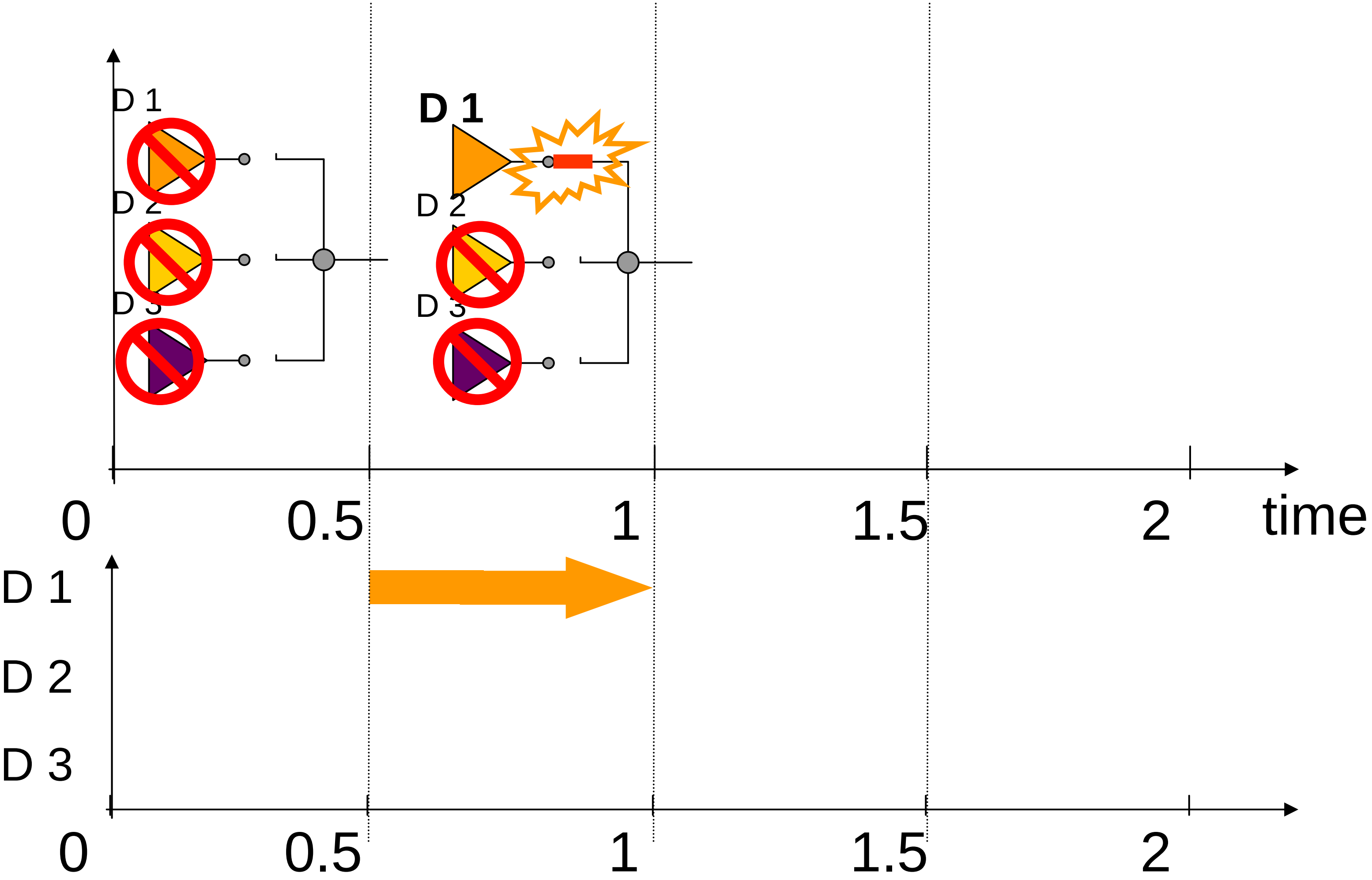
All 3 driver stages are switched off



time schedule   t = 0.5

Driver schedules basics

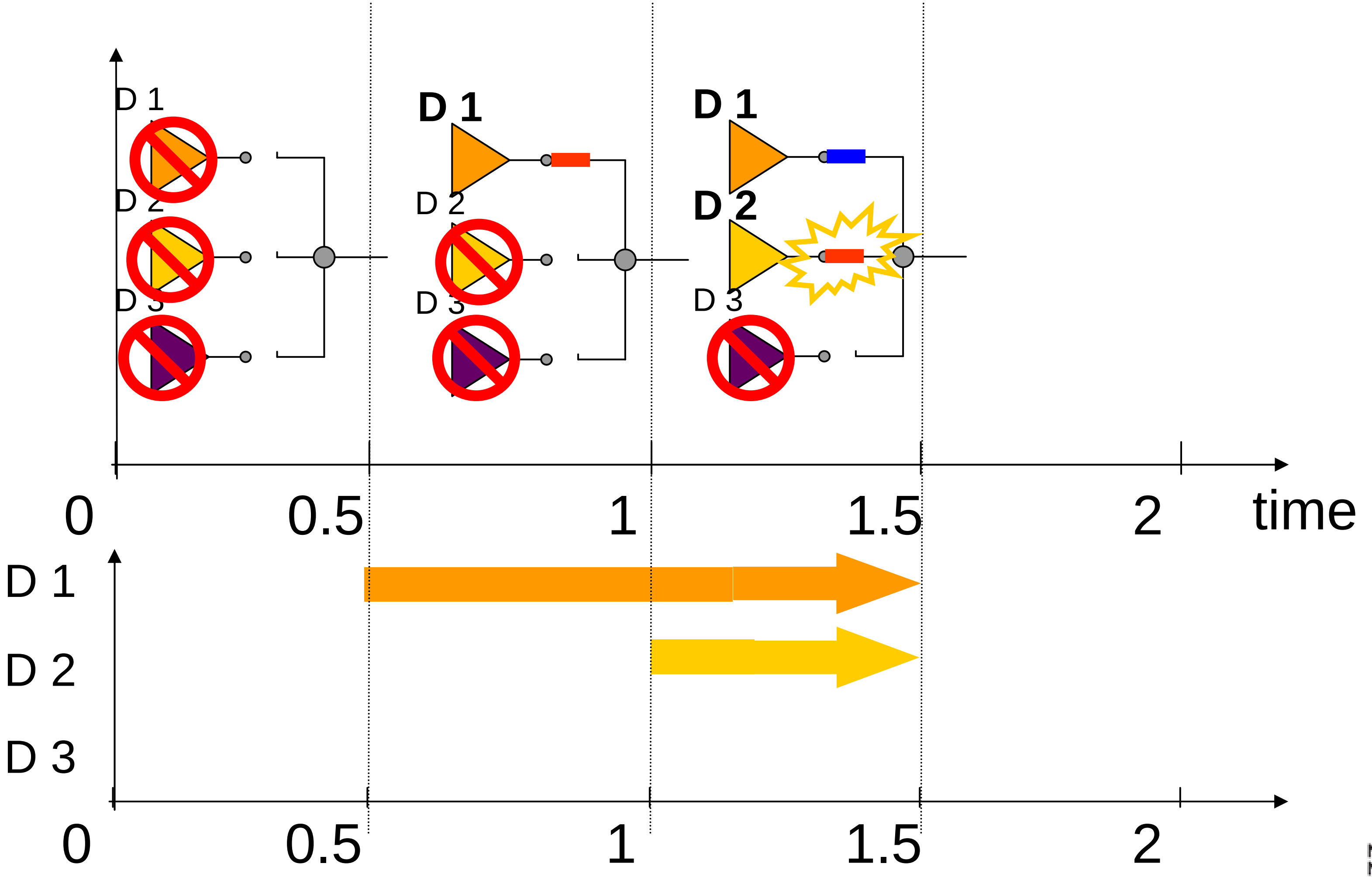
Driver stage D1 is switched on



Driver schedules
basics

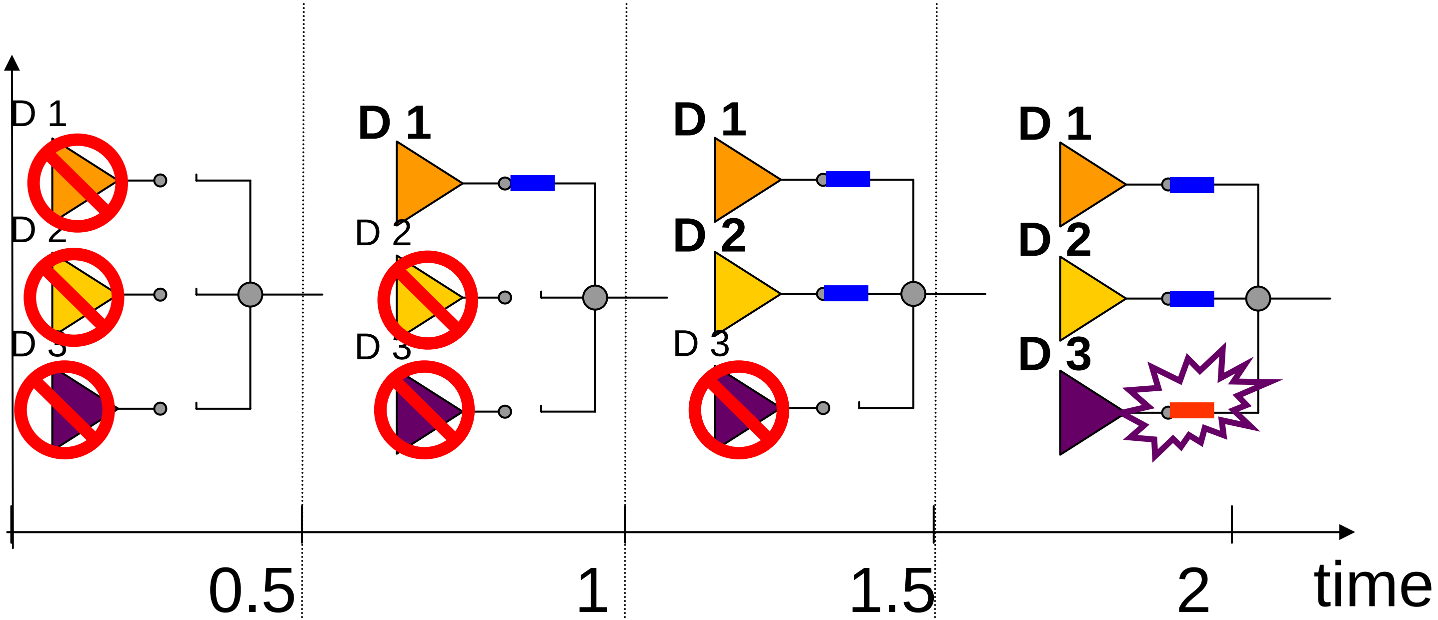
time schedule t = 1

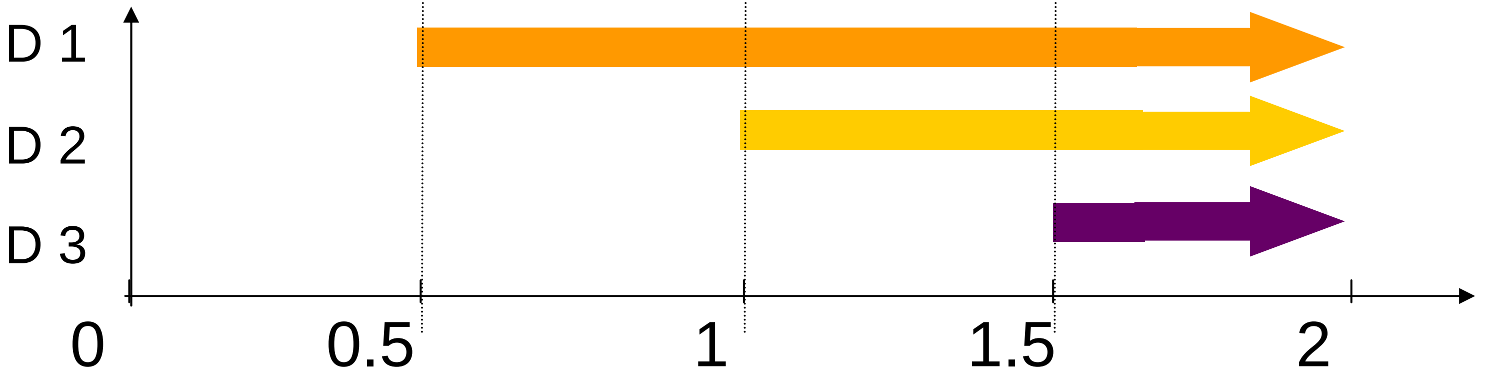
Driver stage D2 is additionally switched on



time schedule t = 1.5

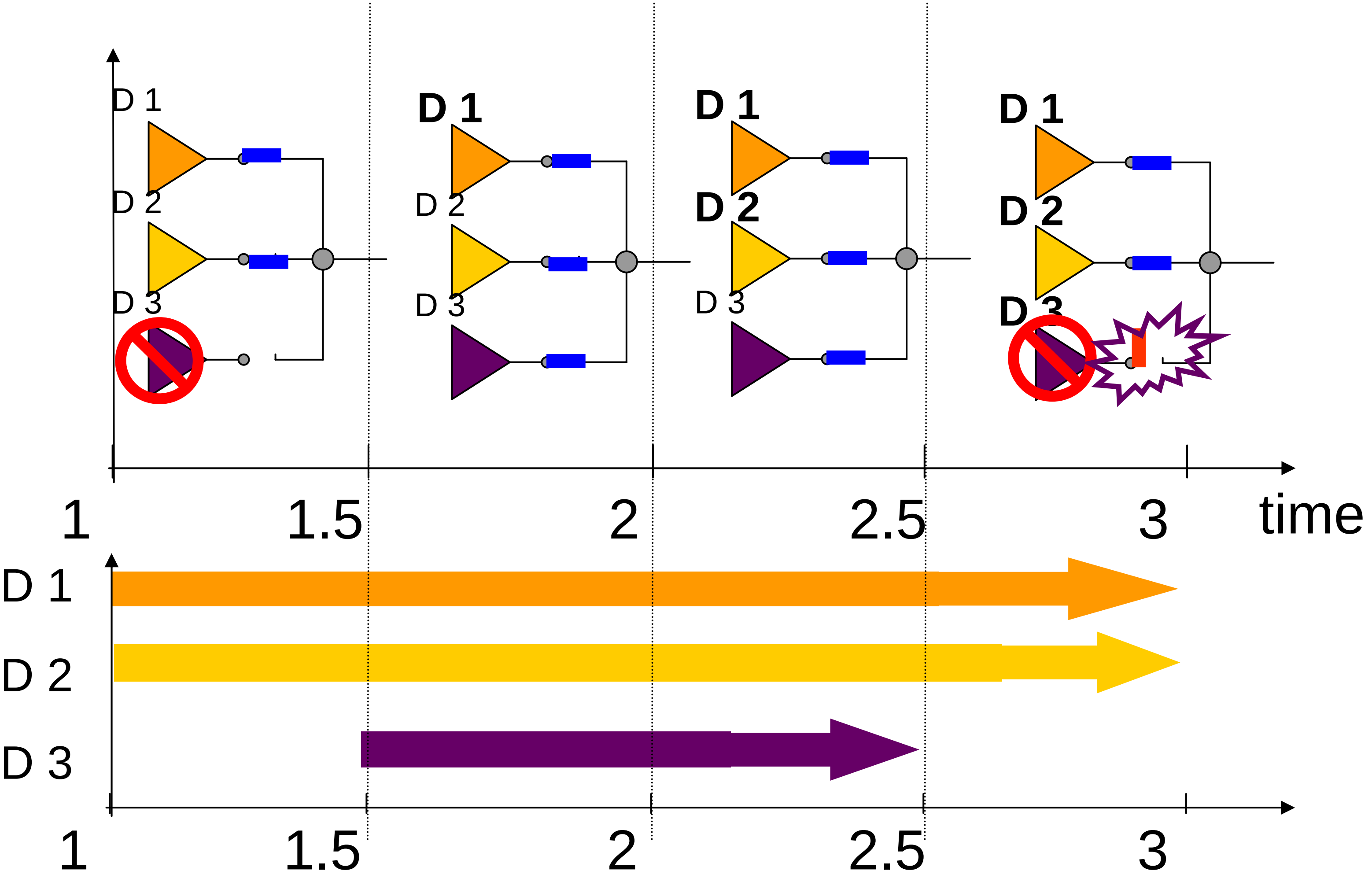
Driver stage D3 is additionally switched on





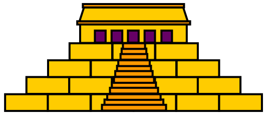
time schedule   t = 2.5

Driver stage D3 is switched off



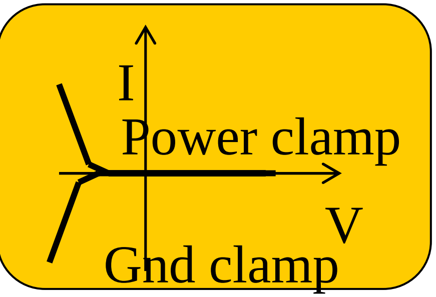
Driver schedules with push-pull (CMOS) Models

Push-pull

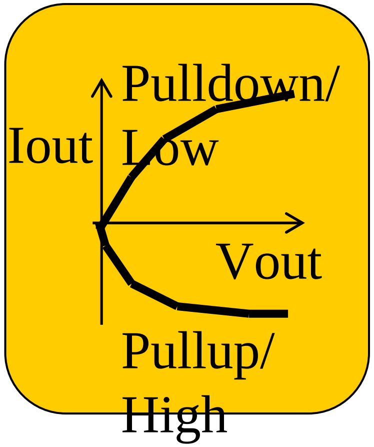


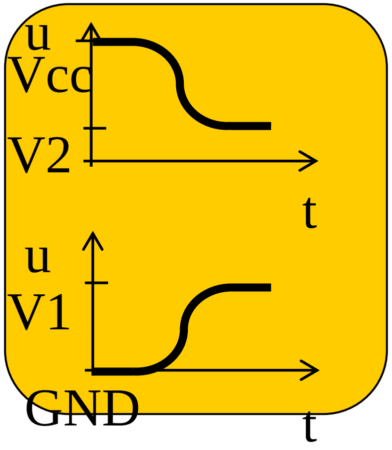
IBIS push pull driver schedule

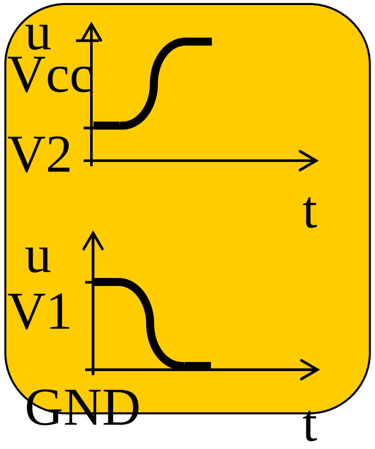
Push-pull

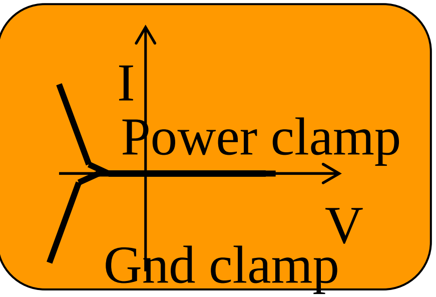


MODEL_1

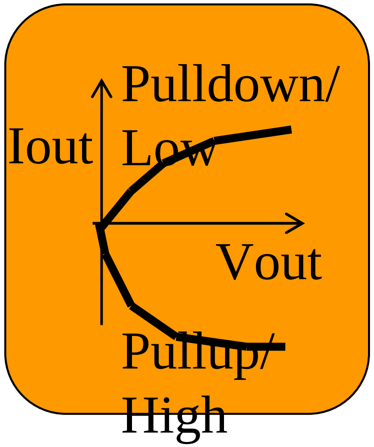


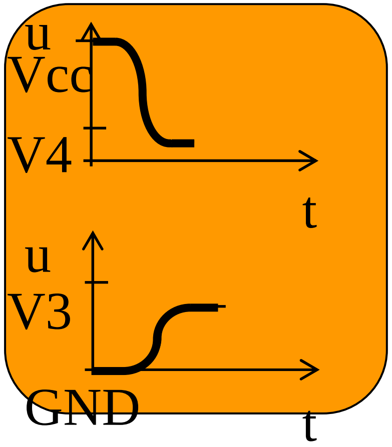


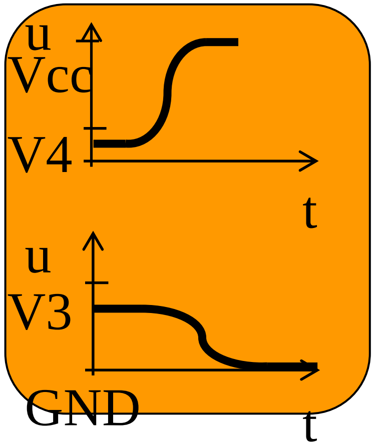




MODEL_2







realization

Push-pull

Example with two IO-Models and no top level model information

……

[Driver schedule]

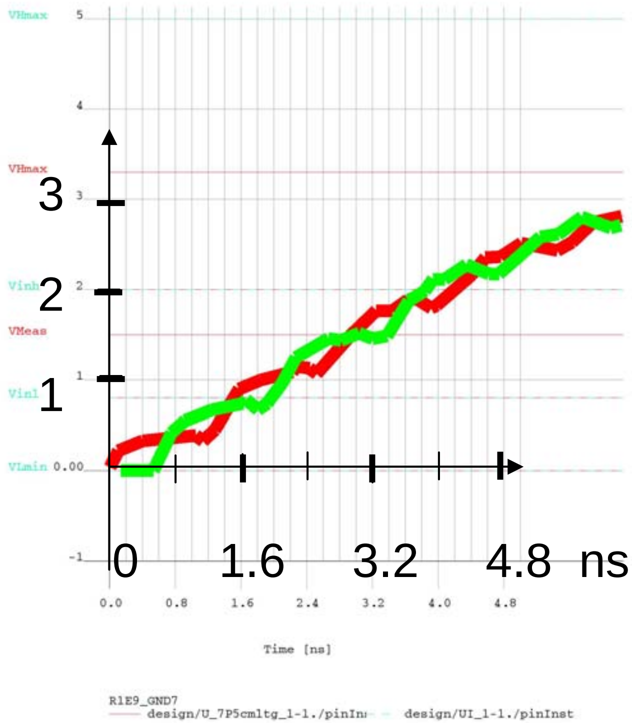
|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**2.00ns**	**NA**	**2.0ns**	**NA**
MODEL_2	**2.50ns**	**NA**	**2.0ns**	**NA**

……..

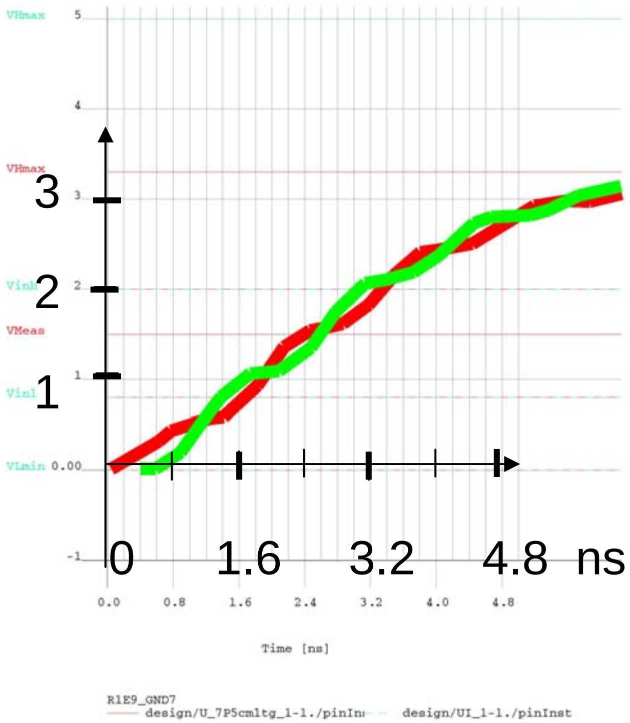
IO-models stand alone

Push-pull

MODEL_1 stand alone



MODEL_2 stand alone



Testload was a 3 inch transmission line (open)

Driver 🟥 End of line 🟩

3 test cases

Push-pull

(examples show only rising edge)

1

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**0.00ns**	**NA**	2.0ns	NA
MODEL_2	**0.00ns**	**NA**	2.0ns	NA

2

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**0.00ns**	**NA**	2.0ns	NA
MODEL_2	**2.50ns**	**NA**	2.0ns	NA

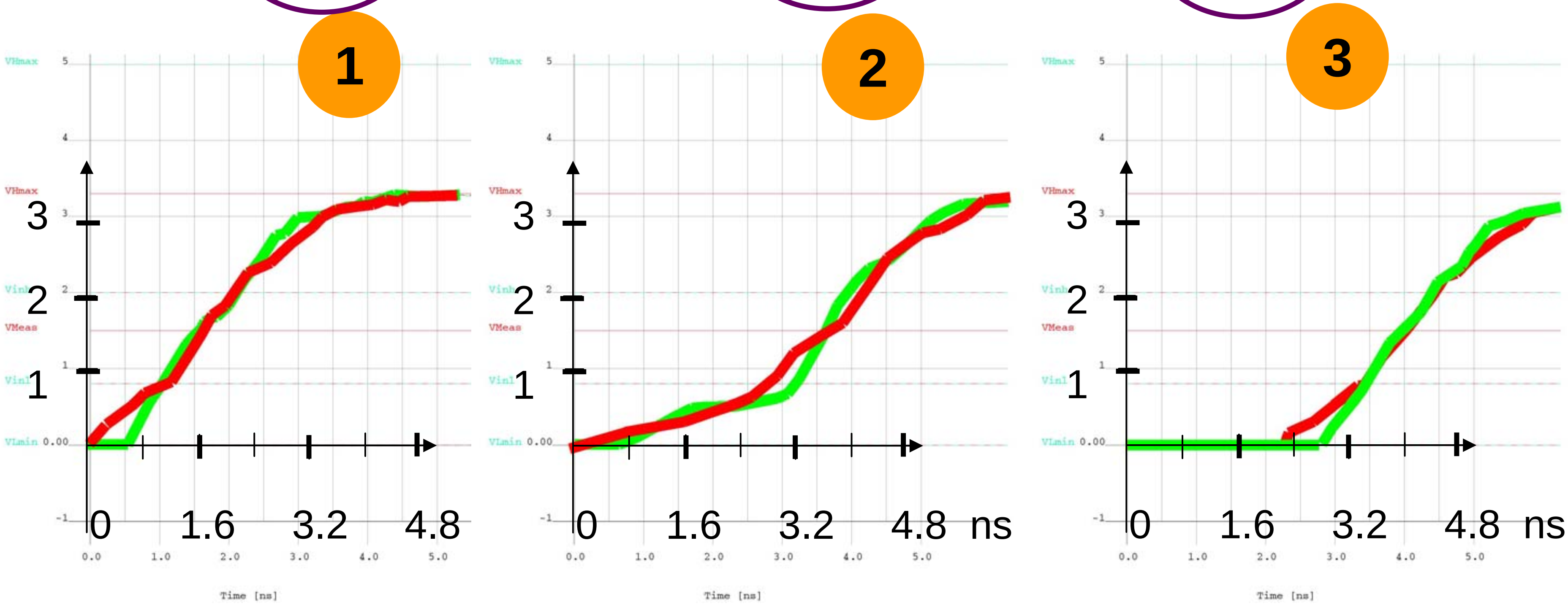
3

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**2.00ns**	**NA**	2.0ns	NA
MODEL_2	**2.50ns**	**NA**	2.0ns	NA

results

Push-pull

```
|Model_name  Rise_on_dly  Rise_off_dly
MODEL_1      0.00ns       NA     0.00ns     NA     2.00ns     NA
MODEL_2      0.00ns       NA     2.50ns     NA     2.50ns     NA
```

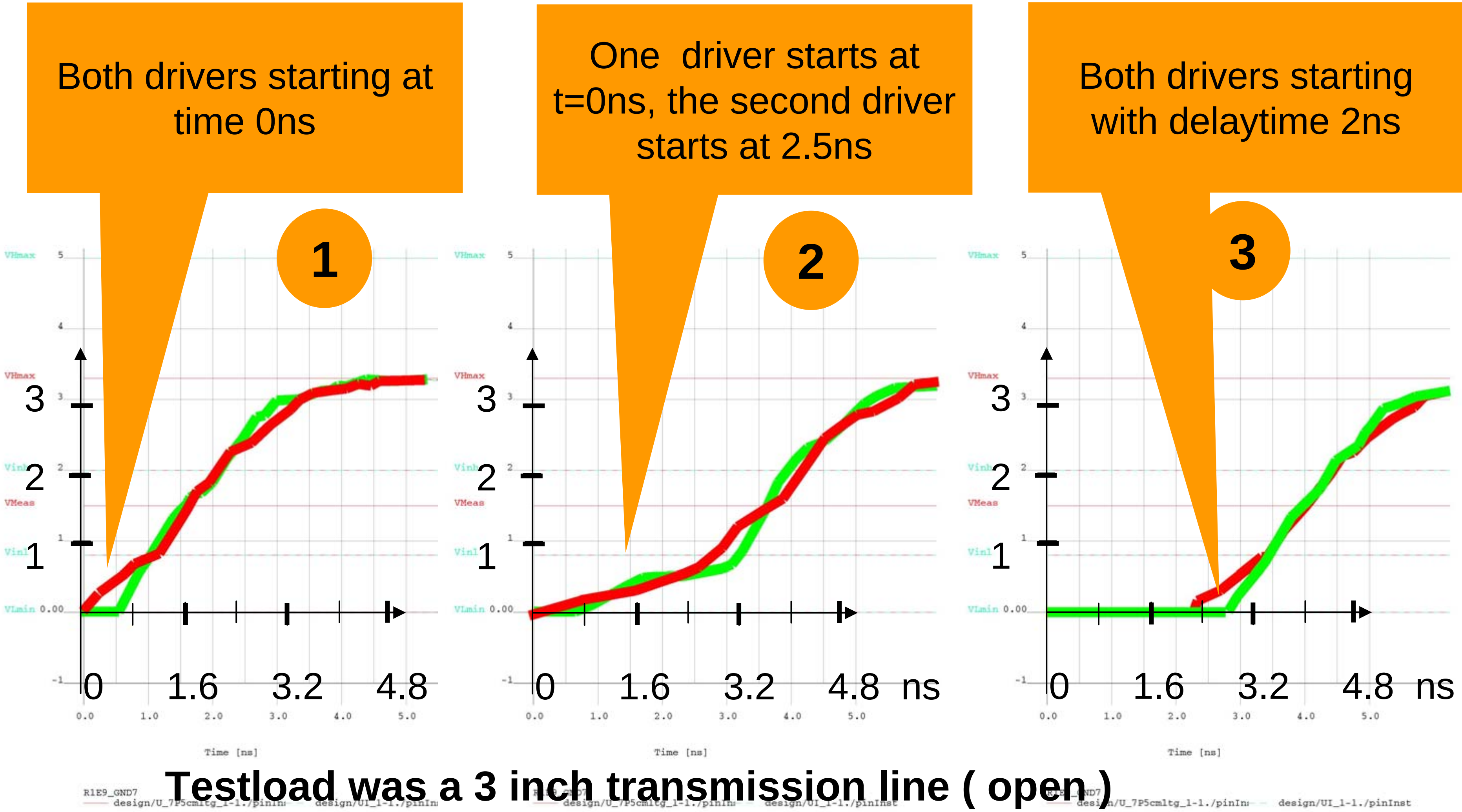


Testload was a 3 inch transmission line (open)

Driver 🟥 End of line 🟩

results with comments

Push-pull



Both drivers starting at time 0ns

One driver starts at t=0ns, the second driver starts at 2.5ns

Both drivers starting with delaytime 2ns

Testload was a 3 inch transmission line (open)

Driver 🟥

End of line 🟩

GTL-like driver schedules

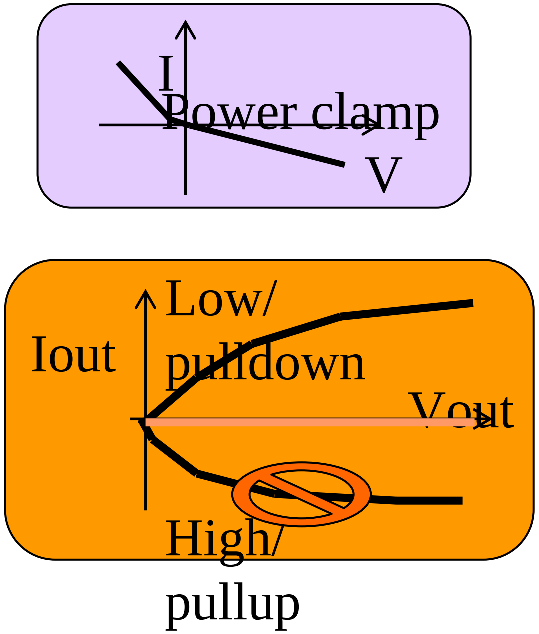
IO models

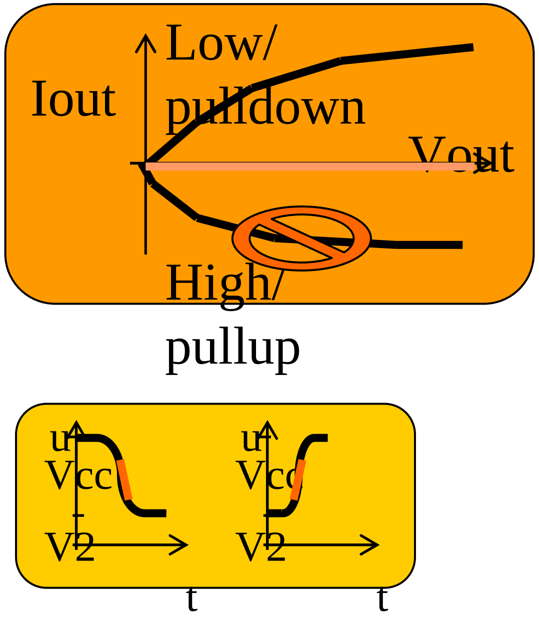
GTL-like

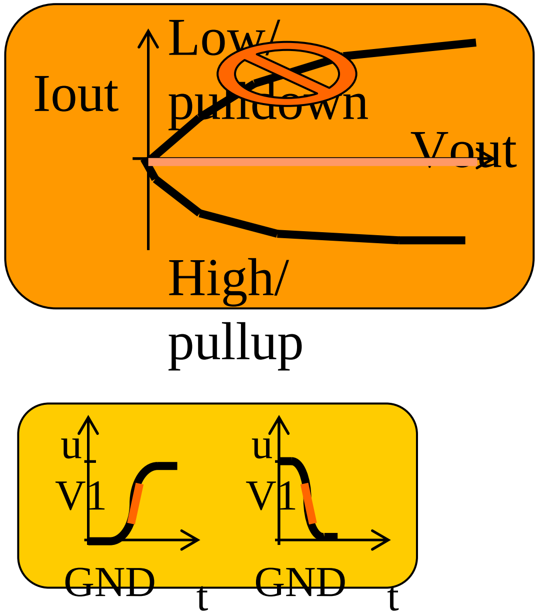
Top level MODEL

MODEL_1

MODEL_2







Example with two IO-Models

and

with top level model information

IBIS gtl driver schedule

[Driver schedule]

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_OPSINK	**0.00ns**	**NA**	**2.0ns**	**NA**
MODEL_OPSOURCE	**0.00ns**	**2.0ns**	**NA**	**NA**

[pullup]

0.0V 0mA

[pulldown]

0.0V 0mA

2.0 35mA

[powerclamp]

0.0V 0mA

2.0V -10mA

[ramp] 0.5V/0.45ns

3 test cases

GTL-like

(here only rising edge shown)

1

Pulldown

Power clamp

Ramp

2

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**0.00ns**	**NA**	2.0ns	NA
~~**|MODEL_2**~~	~~**0.00ns**~~	~~**2.0ns**~~	~~2.0ns~~	~~NA~~

3

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_1	**0.00ns**	**NA**	2.0ns	NA
MODEL_2	**0.00ns**	**2.0ns**	2.0ns	NA

models overview for testcases

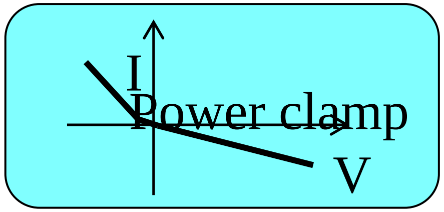
1

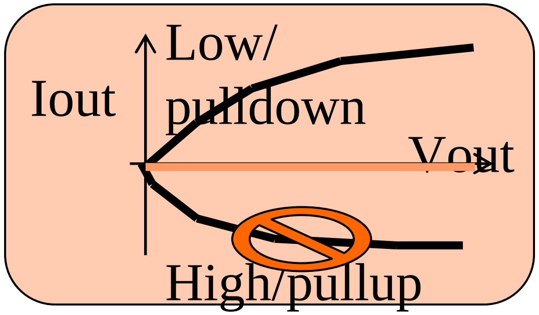
2

3

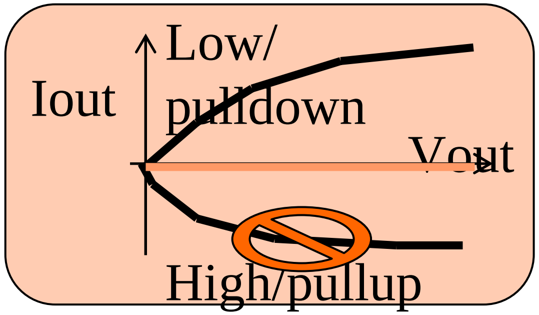
GTL-like

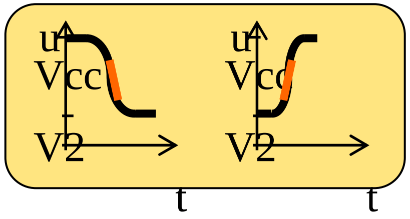
Case 1 top level



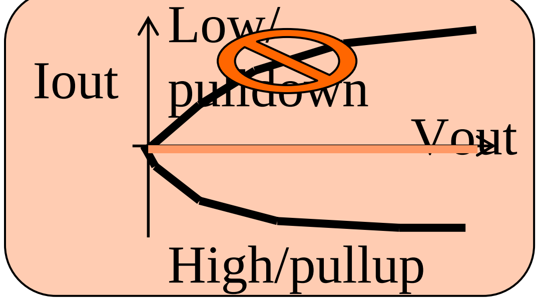


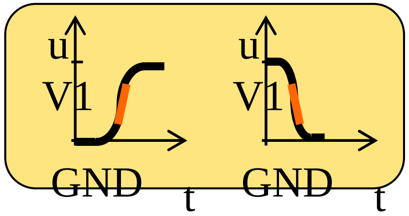
Case 2 Main only

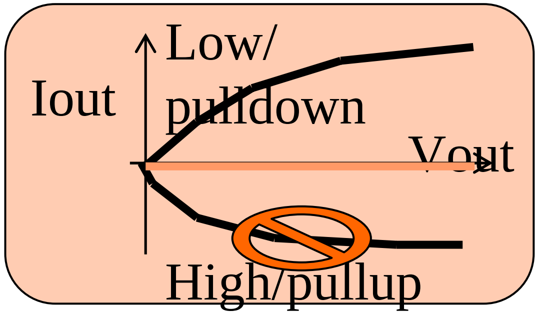


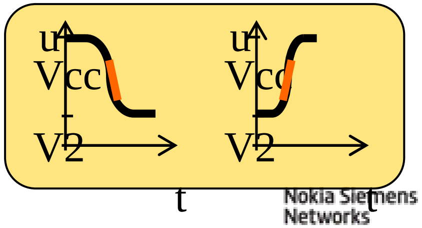


Case 3 scheduled









results

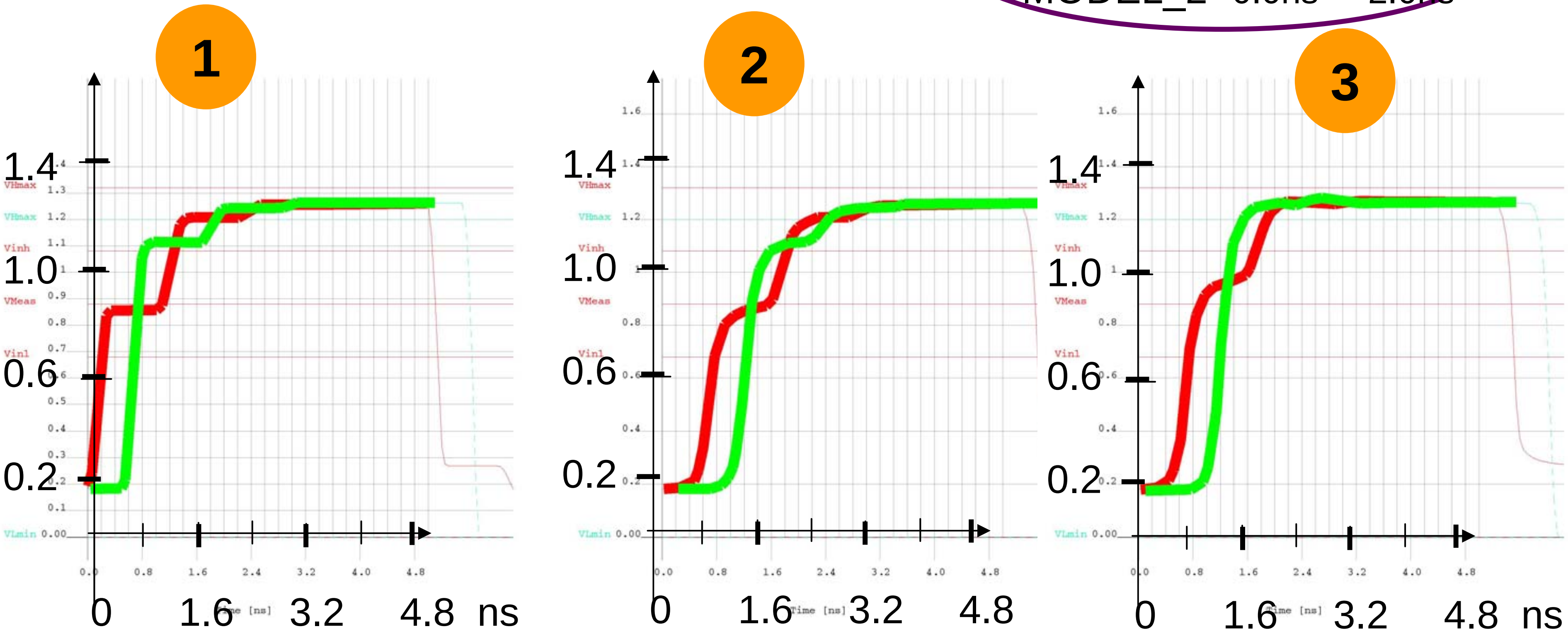
GTL-like

Pulldown

Power clamp

|Model_name	Rise_on_dly	Rise_off_dly
MODEL_1	0.0ns	NA

|Model_name	Rise_on_dly	Rise_off_dly
MODEL_1	0.0ns	NA
MODEL_2	0.0ns	2.0ns

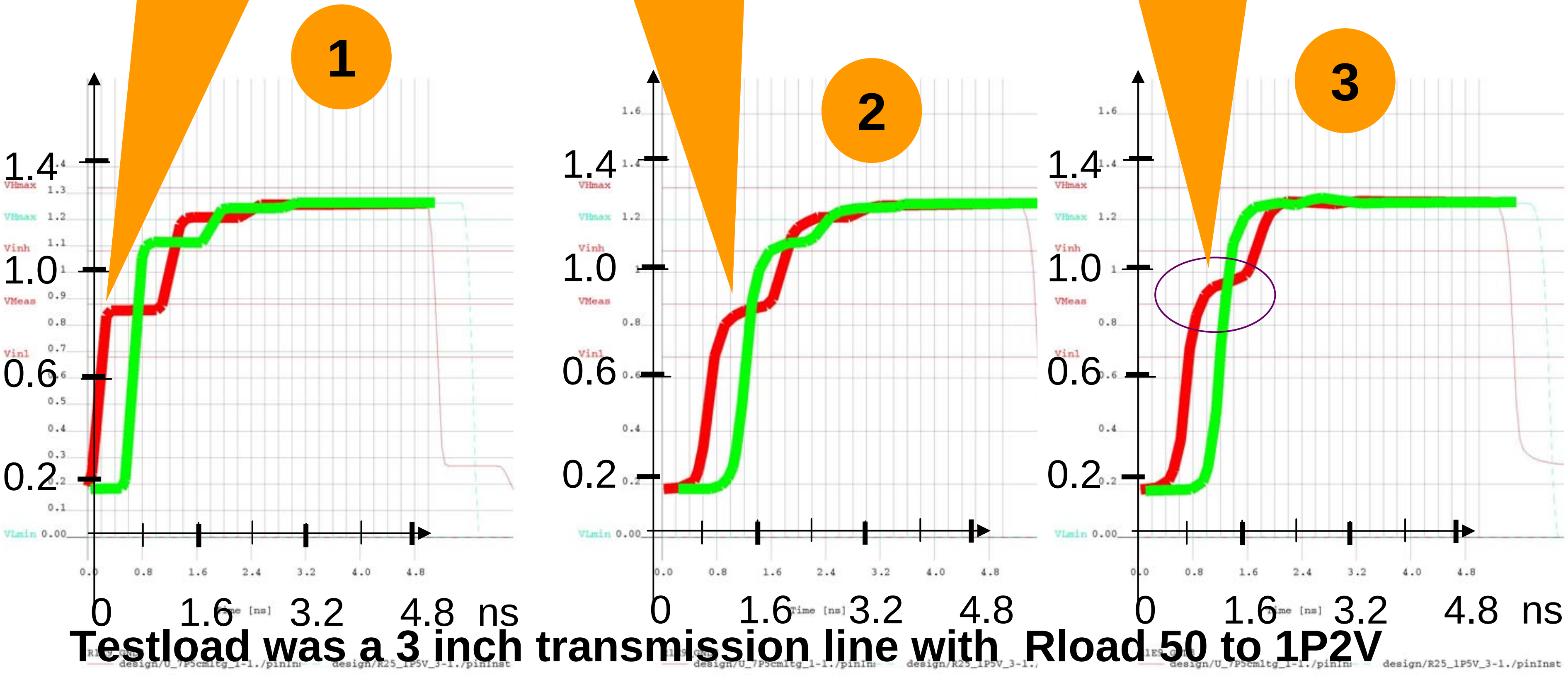


Testload was a 3 inch transmission line with Rload 50 to 1P2V

Driver 🟥 End of line 🟩

GTL-like

results with comments



Ramp only

no accurate rising

rising behavior from external termination

Additional swing by open source driver

Testload was a 3 inch transmission line with Rload 50 to 1P2V

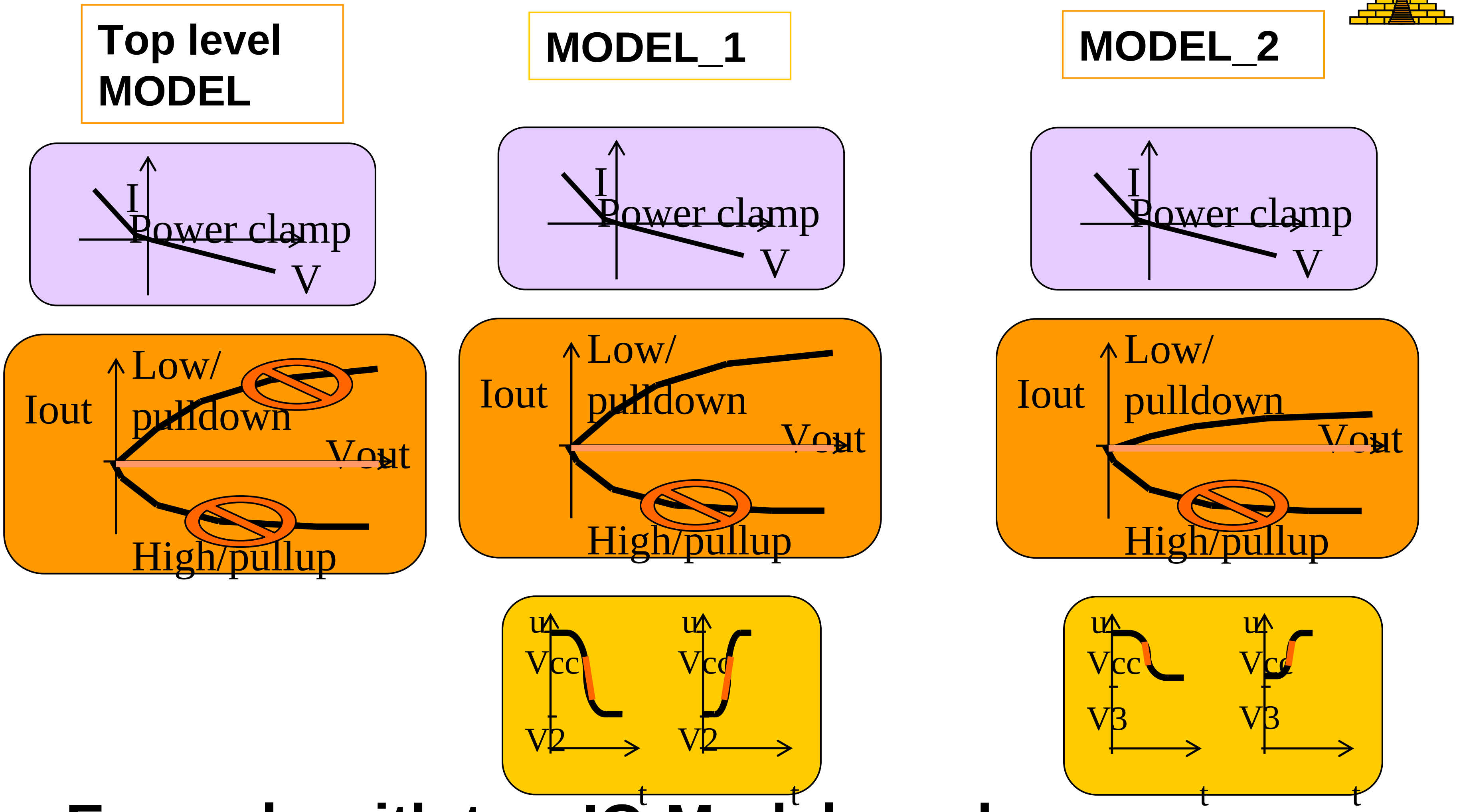
Driver 🟥 End of line 🟩

Public

CML pre-emphasis

IO models

CML-Preemphasis



Top level MODEL

MODEL_1

MODEL_2

Example with two IO-Models and with wrong top level model information

IBIS cml driver schedule

CML-Preemphasis

```
[Driver schedule]
|Model_name      Rise_on_dly   Rise_off_dly   Fall_on_dly   Fall_off_dly
MODEL_OPSINKMAIN          0.00ns      NA        2.0ns      NA
MODEL_OPSINKBOOST     0.00ns     0.8ns      NA            NA
[pullup]
0.0V   0mA
[pulldown]
0.0V   0mA
2.0V   0mA
[powerclamp]
0.0V    0mA
2.0V   -10mA
[ramp]    0.4V/37ps
```

3 test cases

(here only rising edge shown)

1

Pulldown

Power clamp

Ramp

2

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_MAIN	**0.00ns**	**NA**	2.0ns	NA
~~**|MODEL_BOOST**~~	~~**0.00ns**~~	~~**0.8ns**~~	~~2.0ns~~	~~NA~~

3

|Model_name	Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
MODEL_MAIN	**0.00ns**	**NA**	2.0ns	NA
MODEL_BOOST	**0.00ns**	**0.8ns**	2.0ns	NA

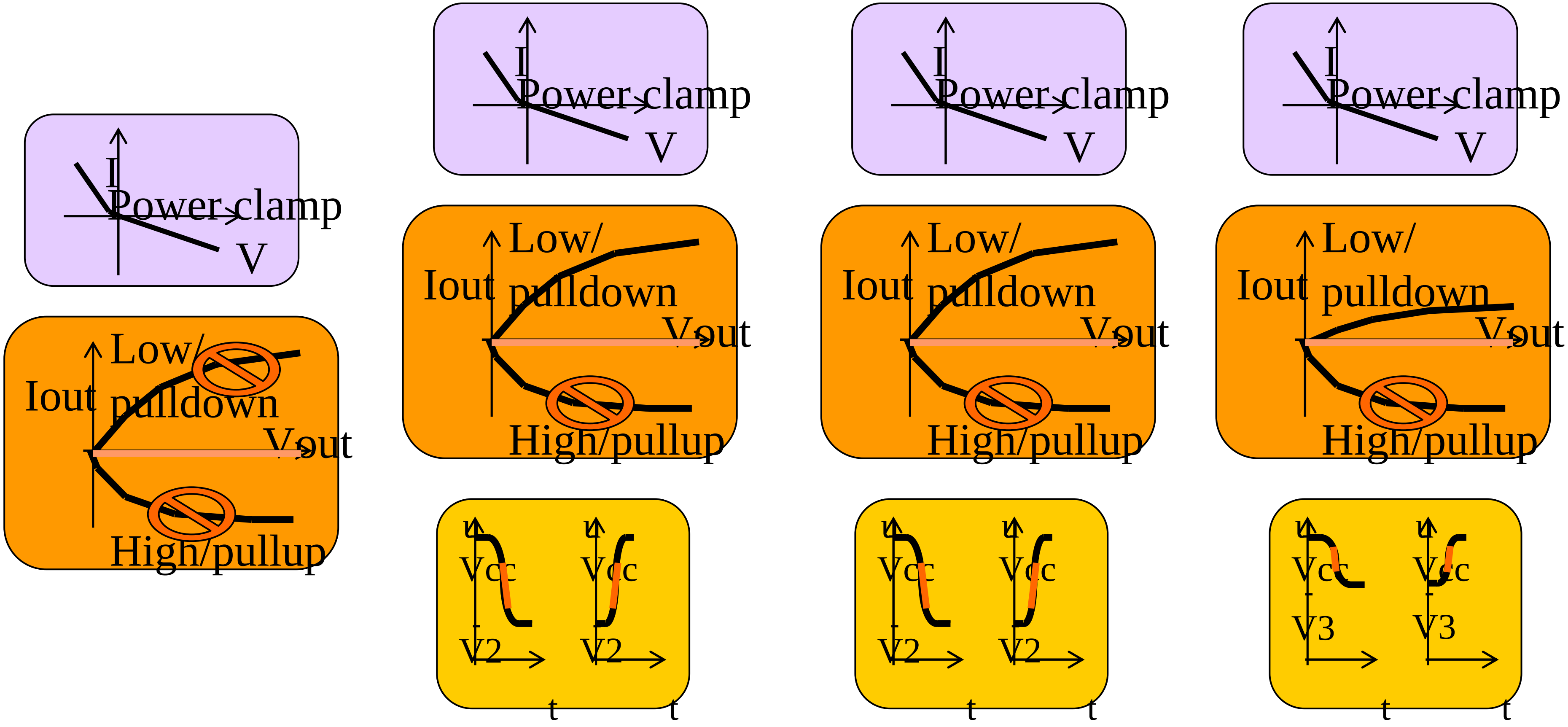
models for test cases

CML-Preemphasis

1 Case 1 top level

2 Case 2 Main only

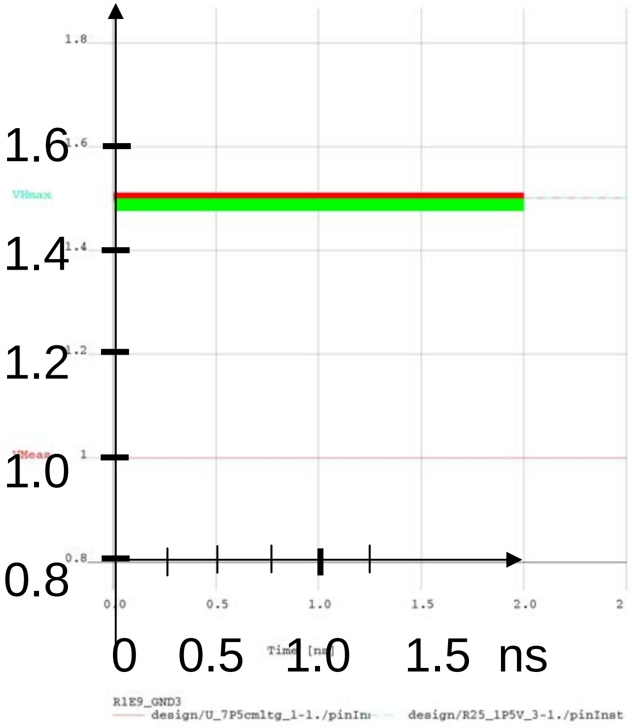
3 Case 3 scheduled



results

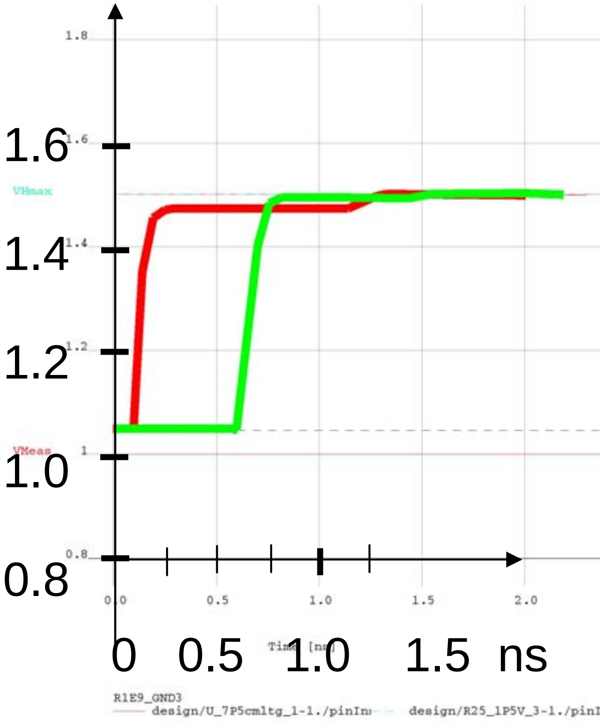
CML-Preemphasis

1



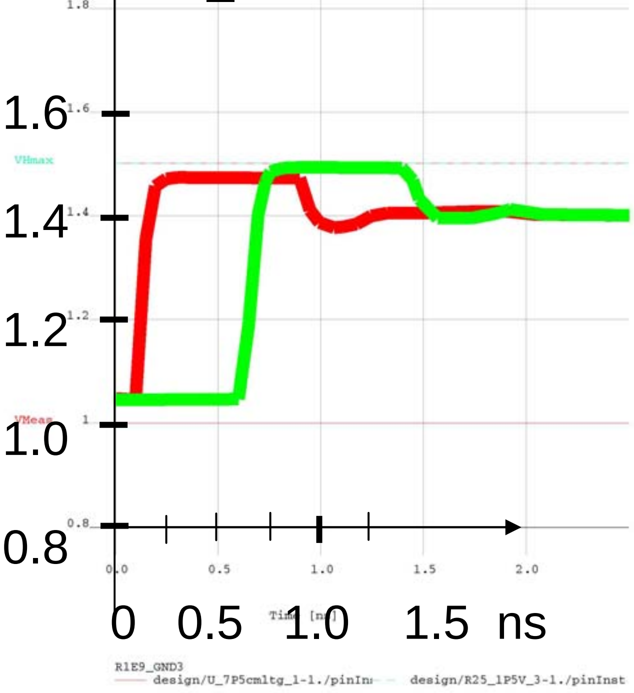
2

|Model_name	Rise_on_dly	Rise_off_dly
MODEL_1	0.0ns	NA



3

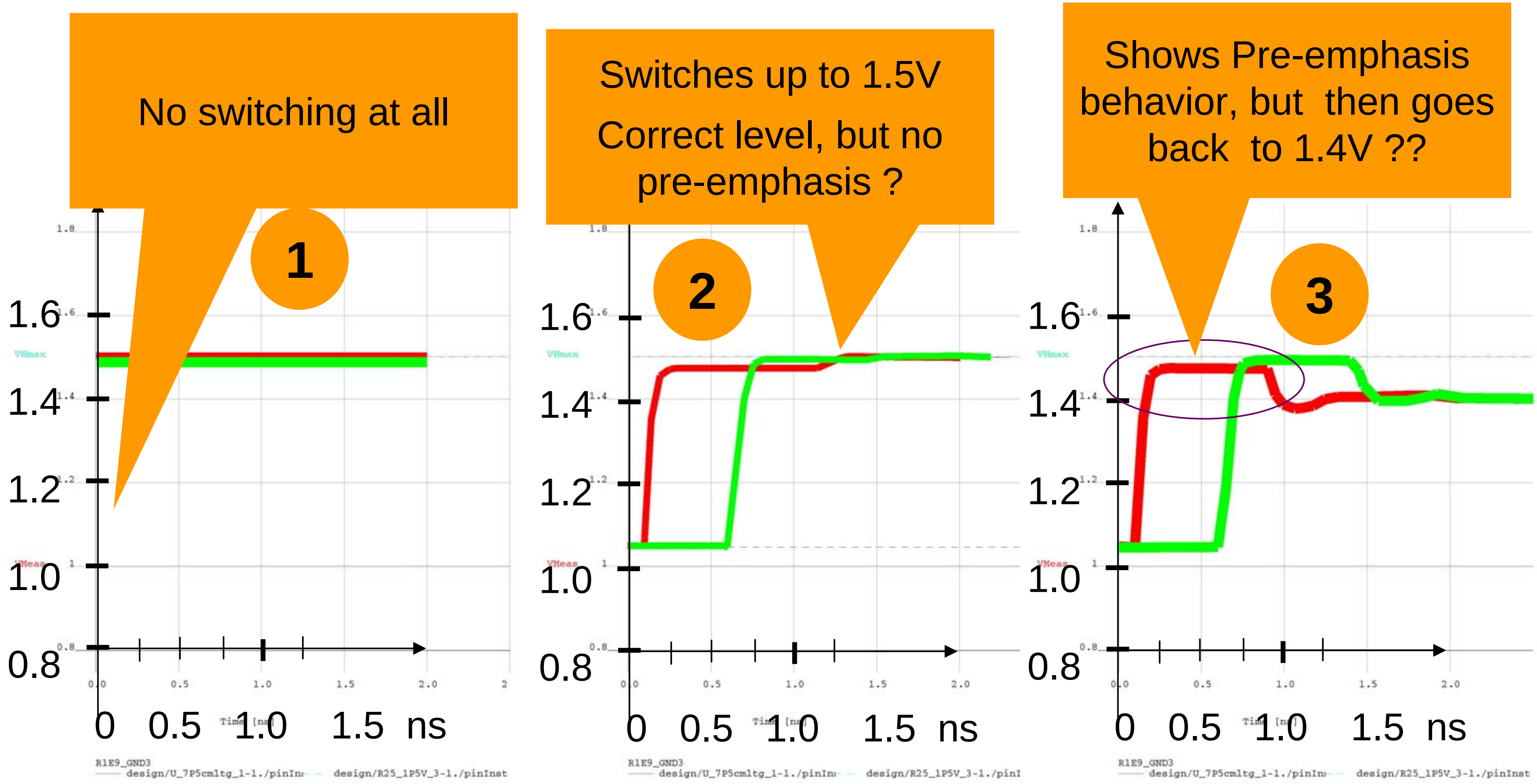
|Model_name	Rise_on_dly	Rise_off_dly
MODEL_1	0.0ns	NA
MODEL_2	0.0ns	0.8ns



Testload was a 3 inch transmission line with Rload 50 to 1P5V

Driver 🟥 End of line 🟩

results with comments



No switching at all

Switches up to 1.5V

Correct level, but no pre-emphasis ?

Shows Pre-emphasis behavior, but then goes back to 1.4V ??

Testload was a 3 inch transmission line with Rload 50 to 1P5V

Driver 🟥 End of line 🟩

Summary

- Timing dependant drivers works fine
- Voltage dependant drivers should be possible with [submodel] and ‚fall-back‘
- Pre-emphasis modeling is possible,
  but only with fixed ‚Pre-emphasis‘
- Pattern dependant ‚Pre-emphasis‘ with VHDL-AMS
- Check of combined static and dynamic waveforms necessary
- Driver schedule models have to be carefully checked

Nokia Siemens Networks

Thank You

- Questions ?