Interpreting the [Driver Schedule] keyword

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Background

- **A new look at BIRD 84.1 revealed a minor but confusing typo in the "ANY OTHER BACKGROUND INFORMATION" section**
  - The ASCII drawing should show the falling edges of the output waveform directly below the rising edges of the input waveform
- **A private email discussion of this subject indicated that there may still be some disagreement or confusion on how the [Driver Schedule] keyword is defined in the IBIS specification**
- **This presentation was written to show with examples what the expected operation of the keyword is based on the IBIS v4.0 specification and BIRD 84.1**
- **If any further clarifications and/or modifications would become necessary as a result of this discussion, a new BIRD will have to be written for implementation in IBIS v4.2 (or later)**
- **This discussion is not intended to delay the vote on IBIS v4.1**

Summary of IBIS specification

Assuming non-inverting polarity

- **Rise_on_dly:**
  - Triggered by rising edge stimulus
    - Pullup ON
    - Pulldown OFF
- **Rise_off_dly:**
  - Triggered by rising edge stimulus
    - Pullup OFF
    - Pulldown ON
- **Fall_on_dly:**
  - Triggered by falling edge stimulus
    - Pulldown ON
    - Pullup OFF
- **Fall_off_dly:**
  - Triggered by falling edge stimulus
    - Pulldown OFF
    - Pullup ON

Whichever comes first

"NA" means "not available" (i.e. without any information we can't do anything) which is *not the same* as a zero delay

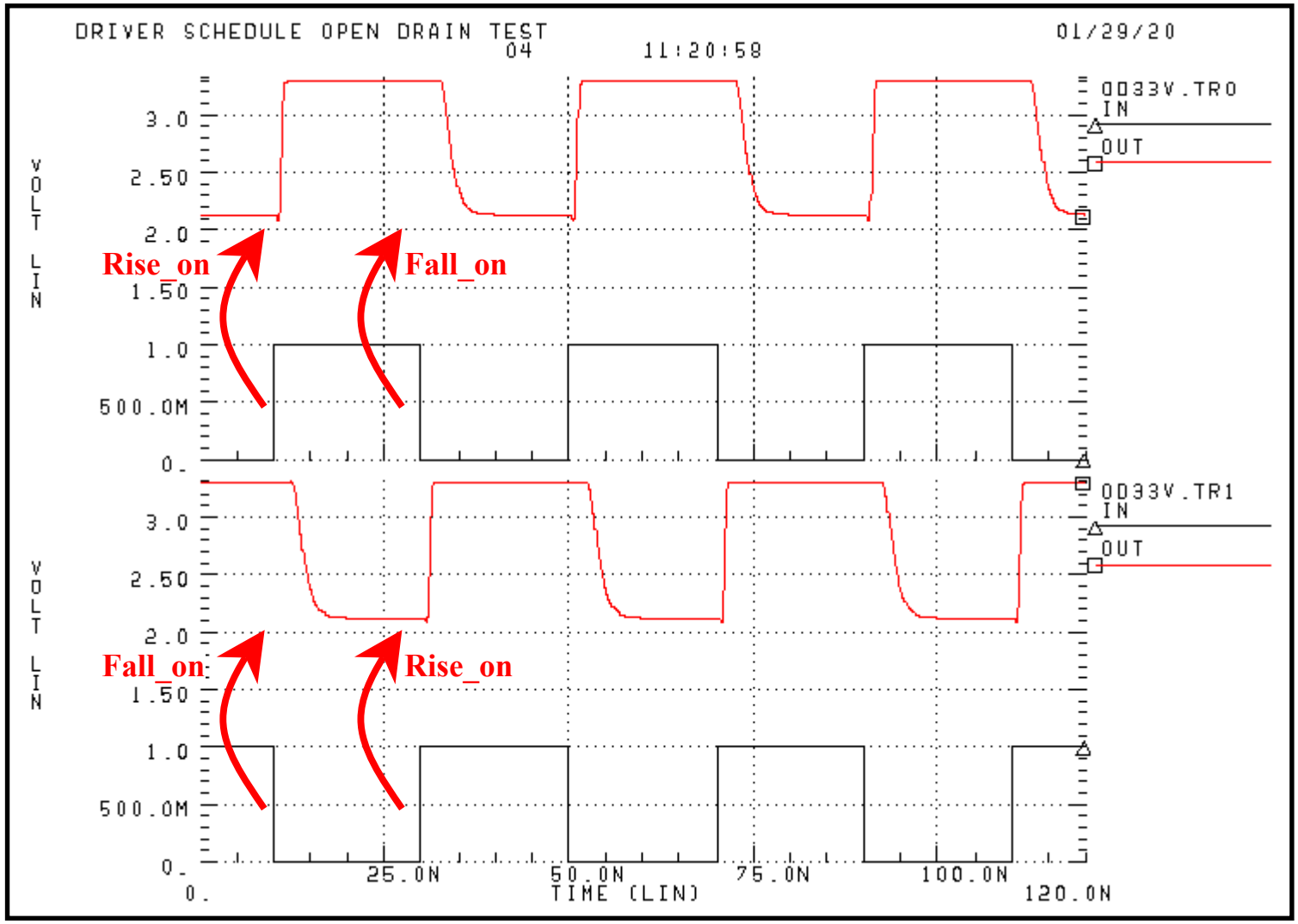
BIRD 84.1 addresses two issues

- **Usage rules of subparameters, most importantly "polarity" were undefined**
  - It was unclear what a simulation tool should do if the polarity subparameter existed in both the scheduled [Model]s as well as the top level model, perhaps containing conflicting information
  - The BIRD basically says that the subparameters of the scheduled [Model]s will be ignored and the subparameters of the top level model will be used
- **The word "event" was undefined in the usage rules section discussing the delay parameters**
  - Different interpretations existed leading to different simulation results

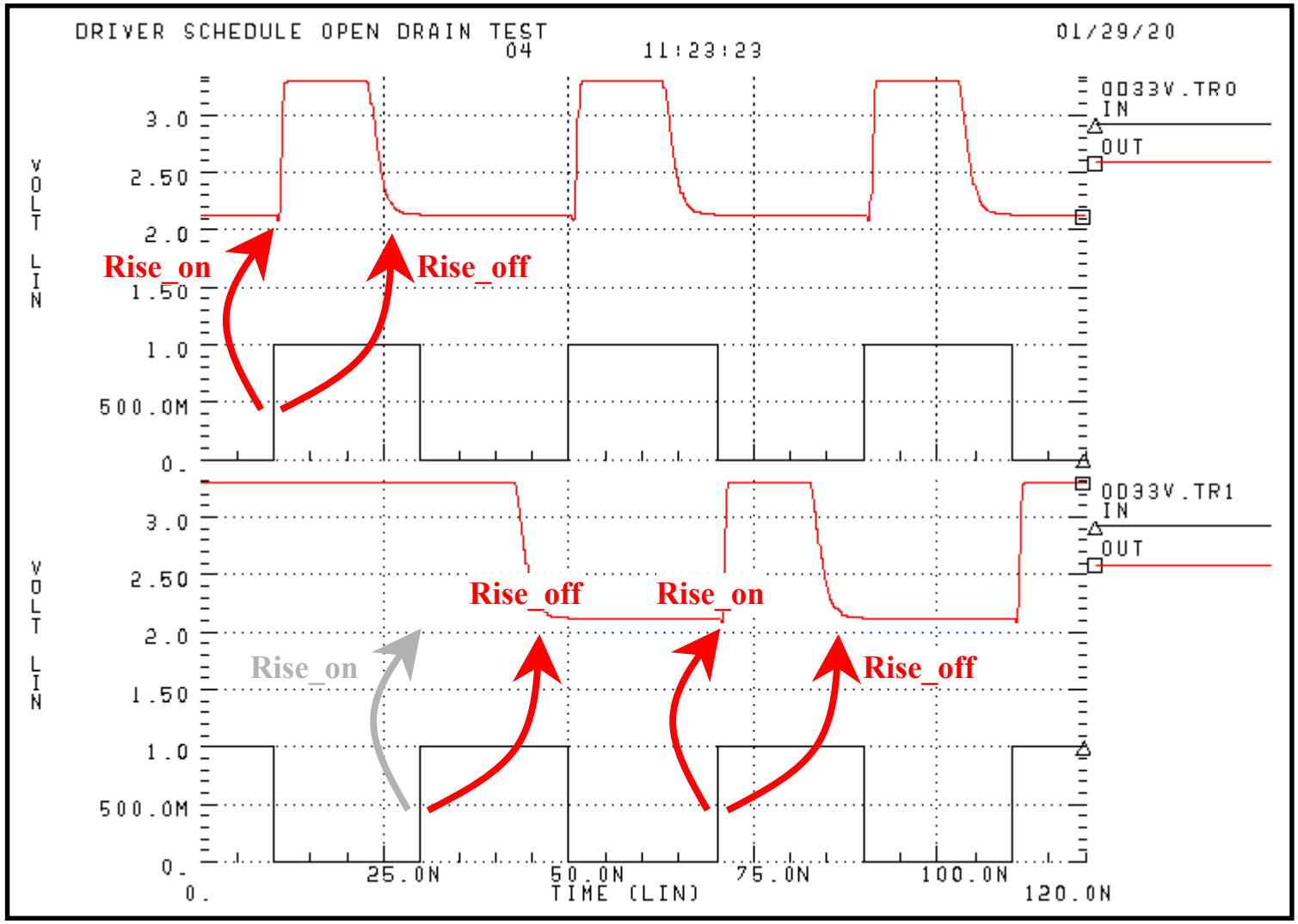
Still missing information in the IBIS specification

- **The IBIS specification doesn't say how the initial conditions should be calculated**
  - May need to write a new BIRD on this if it becomes important to define it
- **One approach is to use the level of the input stimulus and drive the output accordingly**
  - If polarity is non-inverting, output has the same level as input
  - If polarity is inverting, output has the opposite level as input
- **Another approach is to use the first transition of the stimulus and reverse engineer the initial output level based on the delay parameters so that the first input transition would always result in a transition on the output**
  - This approach is more demanding on the simulator algorithms and may involve some "time travel"

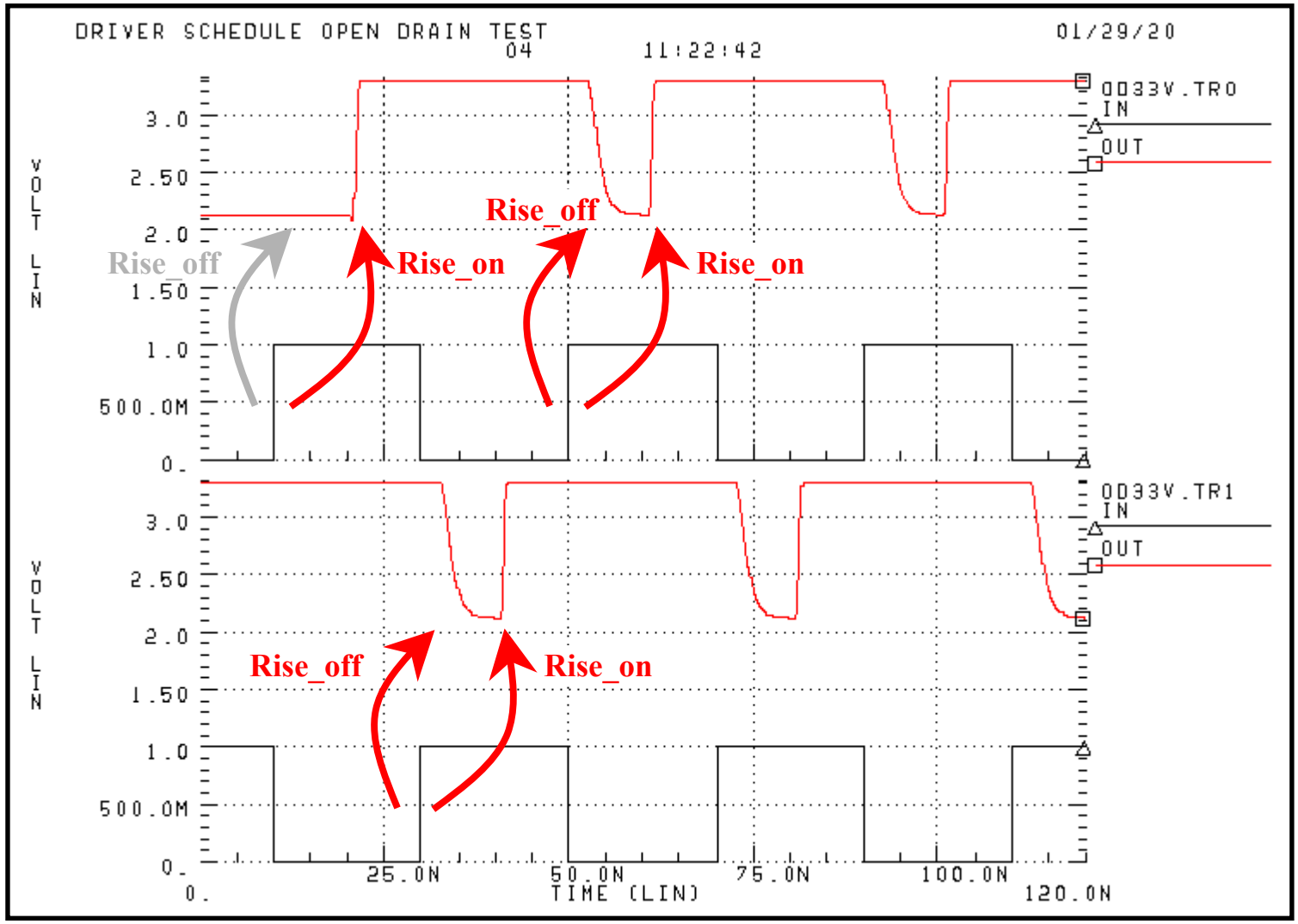
Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
0.0ns	NA	0.0ns	NA



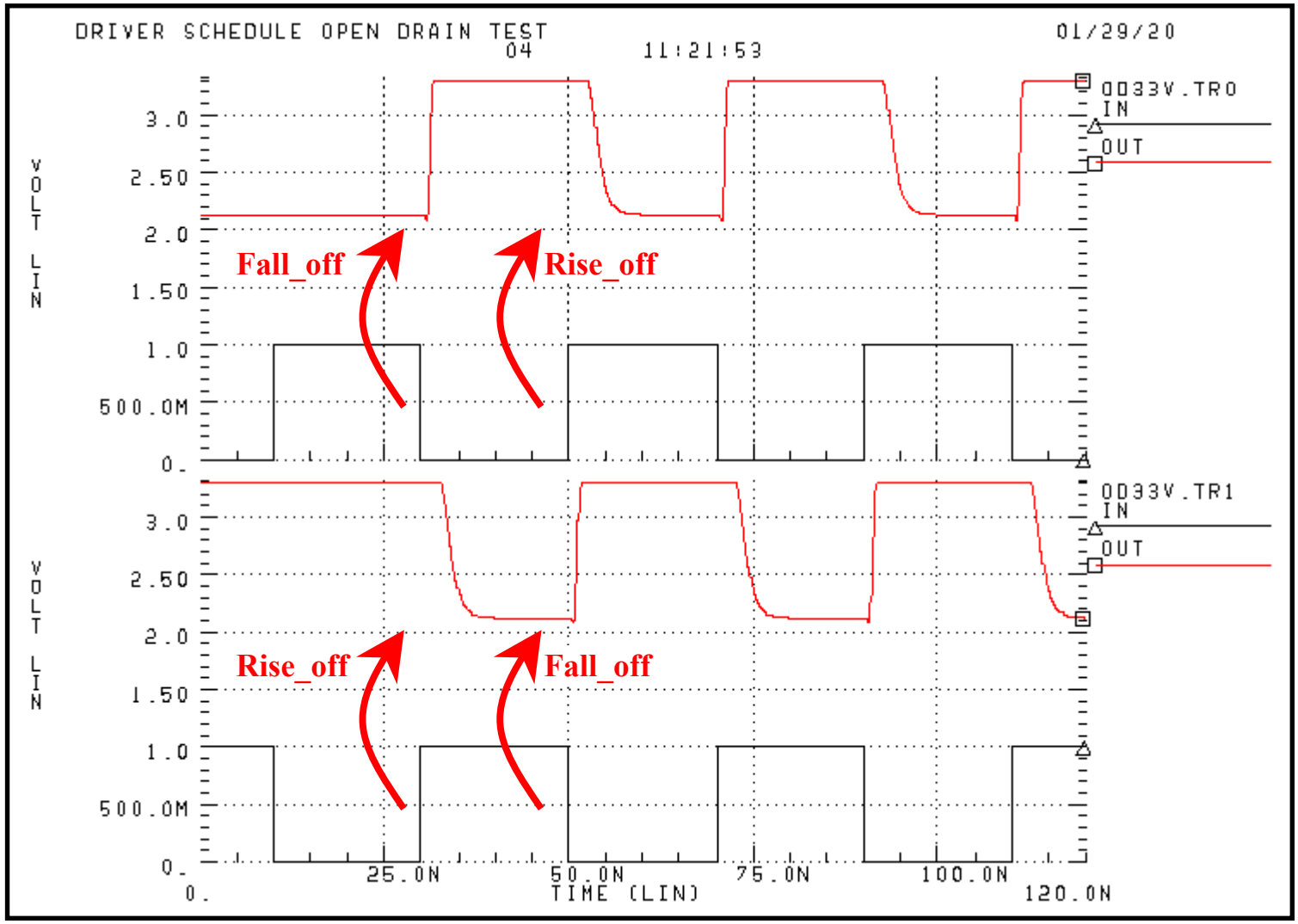
Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
0.0ns	10.0ns	NA	NA



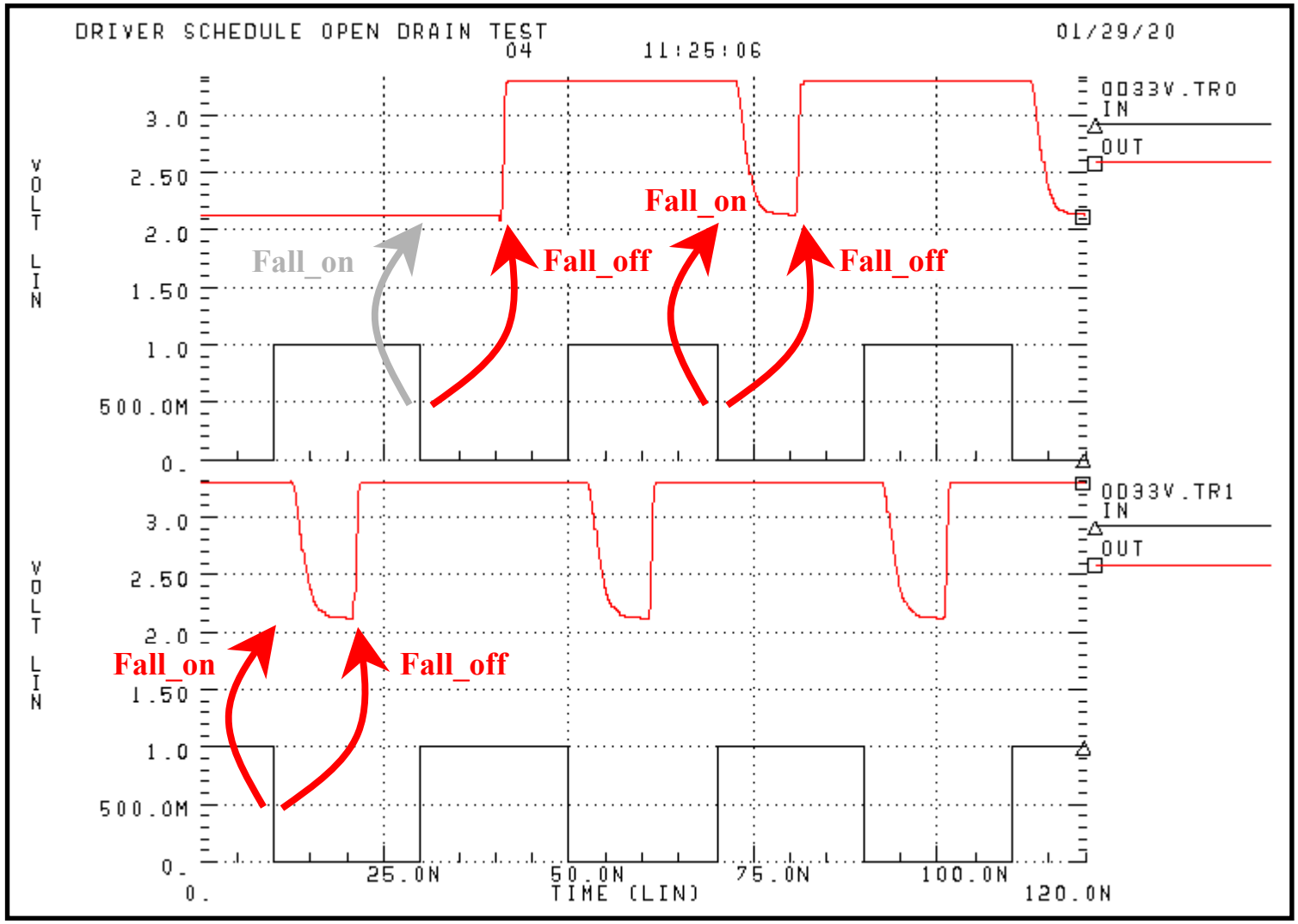
Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
10.0ns	0.0ns	NA	NA



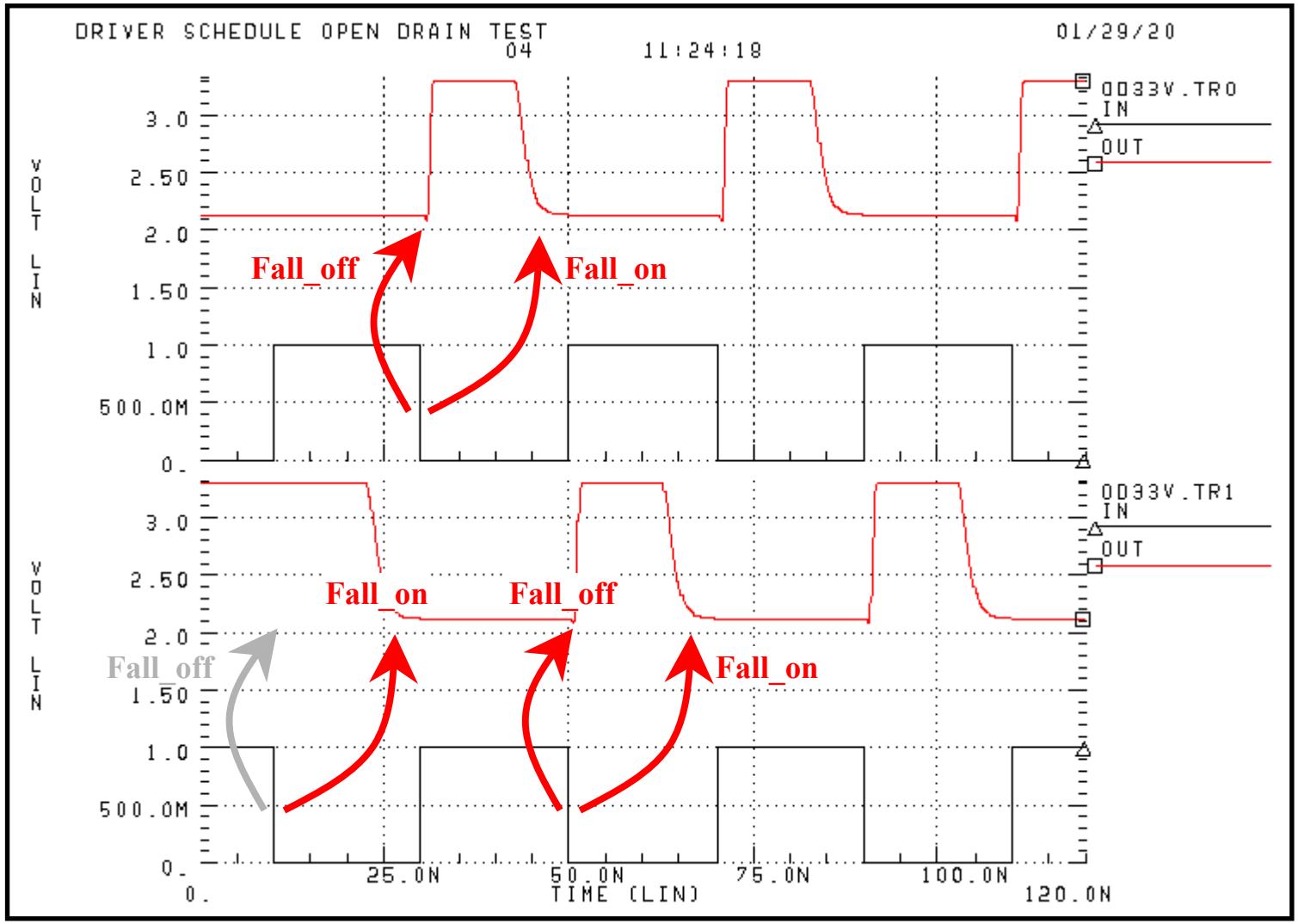
Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
NA	0.0ns	NA	0.0ns



Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
NA	NA	0.0ns	10.0ns



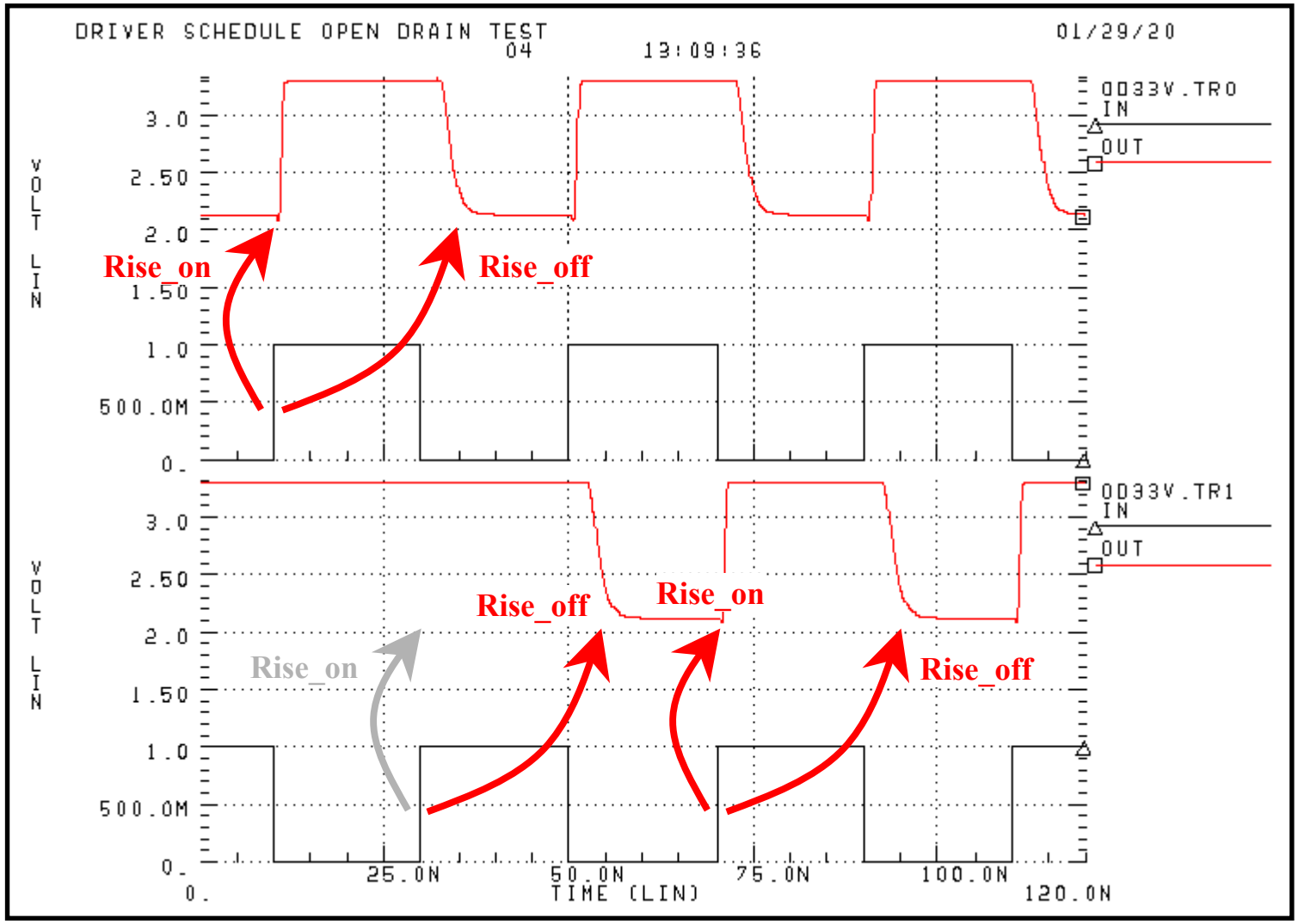
Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
NA	NA	10.0ns	0.0ns



Over clocking

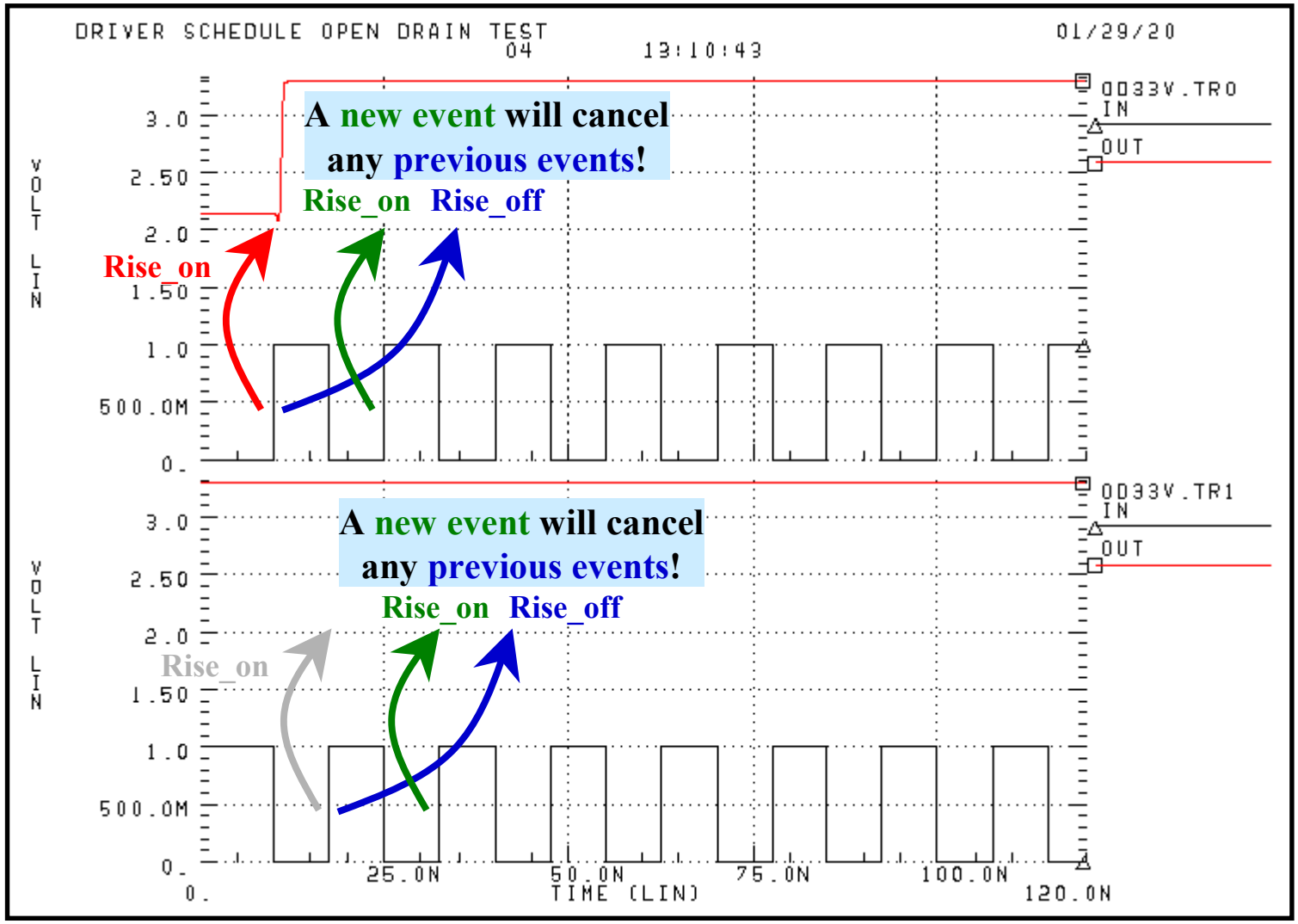
- **This condition was not addressed in the IBIS specification (up to version 4.0)**
- **BIRD 84.1 addresses what should happen when over clocking occurs**
- **There were two possible options:**
  - A transition on the input stimulus will reset ***any*** previous unexpired time delays
    - This means that the t = 0 time of the waveform tables can only be started by the input stimulus (a time delay later if not cancelled by another transition on the input)
  - Time delays in action are allowed to run their course regardless of new transitions on the input stimulus
    - This means that the t = 0 time of the waveform tables are started by the expiring time delays
- **The first option was chosen because that behavior is consistent with how over clocked waveform tables work**

Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
0.0ns	20.0ns	NA	NA



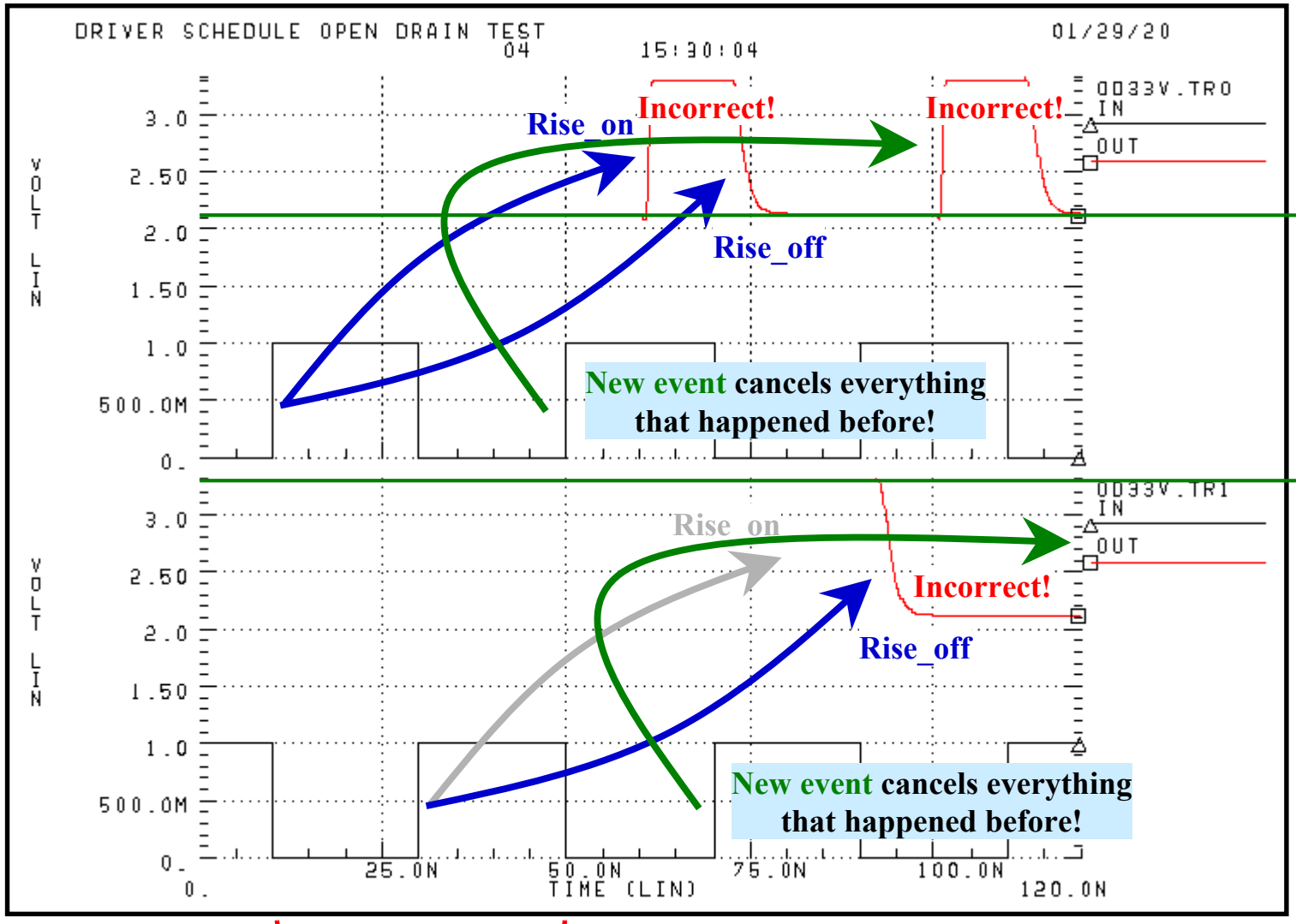
40 ns - (not over clocked)

Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
0.0ns	20.0ns	NA	NA



15 ns - over clocked!

Rise_on_dly	Rise_off_dly	Fall_on_dly	Fall_off_dly
50.0ns	60.0ns	NA	NA



Conclusion

- **BIRD 84.1 clarifies two issues**
  - This helps tool vendors to implement the response without ambiguities
- **BIRD 84.1 fails to clarify how to determine initial conditions**
  - This may result in different waveforms between tools
  - However, it does not have a significant impact on the usual signal integrity simulations to obtain timing measurements
- **The [Driver Schedule] keyword does not cover all possible situations involving multi-staged and/or Pre/De-emphasis buffers**
  - The keyword was always viewed as an interim solution from its conception
  - The limitations can now be overcome by using the new language extensions of the IBIS specification