

Simulating Digital Systems – a reflected view onto the simulation tool landscape

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Overview

- Introduction
- Digital Simulator v5.57
- Digital by Helmut Neemann
- Circuitverse
- Conclusion

Introduction

- Development of digital systems: **multistep process**
 - Specifying requirements
 - Specifying functions
 - Designing the logic of the system
 - Generating a schematic
 - **Simulating the system**
 - Generating a layout / producing a PCB
 - Verifying the design

General Remarks on Digital Simulators

- Provide necessary elements: IO-elements, gates, datapath components (e.g. multiplexers), flipflops, etc.
- Provide the possibility to monitor certain input and output signals
- At the 1st glance: Simulators seem very similar, however:
- When working with a specific simulator there are quite some differences regarding
 - Capabilities
 - Handling
 - Intended use
- Example: simple RS-Latch based on NOR-Gates

Digital Simulator v5.57

➤ Simulator created by Andreas Hertz group

➤ Simulator available at:

<https://sourceforge.net/projects/digisimulator/files/install%20EXE/5.57/DigitalSimulatorV5.57.exe/download>

Digital Simulator v5.57

The screenshot displays the Digital Simulator v5.57 interface. The main window shows a circuit diagram for an RS latch (RS_latch_nor.dsim). The circuit consists of two NOR gates. The first NOR gate has inputs S and Q, and its output is NQ. The second NOR gate has inputs R and NQ, and its output is Q. The outputs NQ and Q are connected to red LEDs. The input S is connected to a switch, and the input R is connected to a switch. The timing diagram below the circuit shows the signals S, R, and Q over time. The signal S is a square wave that is high for a period, then low, then high again. The signal R is a square wave that is high for a period, then low, then high again. The signal Q is a square wave that is high when S is high and R is low, and low when R is high and S is low. The signal NQ is the complement of Q.

RS_latch_nor.dsim

S: [Switch] → [NOR Gate] → NQ → [LED]

R: [Switch] → [NOR Gate] → Q → [LED]

Timing Diagram:

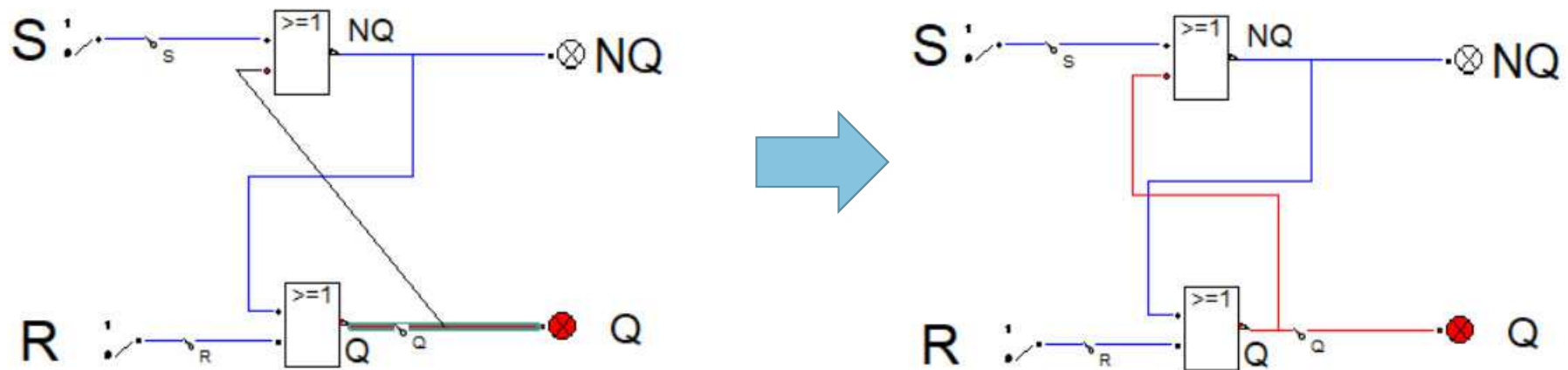
- S: High, Low, High
- R: Low, High, Low
- Q: High, Low, High
- NQ: Low, High, Low

Component Palette:

- Gatter: &, >=1, =1, 1
- FlipFlop
- Schalter
- Register
- Programmier Beispiele
- Selektoren
- ALU
- Allgemein
- Konverter
- Anzeige
- Interface
- Zähler

Digital Simulator v5.57

- Wiring extremely intuitive and quick!
- Rectangular wiring maintained, when repositioning elements!



Digital Simulator v5.57 – regular operation of RS latch

The screenshot displays the Digital Simulator v5.57 interface. The main window shows a circuit diagram of an RS latch implemented with two NOR gates. The set input (S) is connected to the top input of the first NOR gate, and the reset input (R) is connected to the top input of the second NOR gate. The output of the first NOR gate is NQ, and the output of the second NOR gate is Q. The timing diagram below the circuit shows the signals S, R, and Q over time. The S signal is a square wave that transitions from low to high and back to low. The R signal is a square wave that transitions from low to high and back to low. The Q signal is a square wave that transitions from low to high when S transitions from low to high, and from high to low when R transitions from low to high. A red arrow points to the right side of the timing diagram, indicating the direction of time flow.

Major disadvantage of digital simulator v5.57:
Time axis right to left!

Digital Simulator v5.57 – oscillating RS latch (race condition)

The screenshot displays the Digital Simulator v5.57 interface. The main window shows a circuit diagram of an RS latch with a race condition. The circuit consists of two NOR gates. The top NOR gate has inputs 'S' and 'Q', and its output is 'NQ'. The bottom NOR gate has inputs 'S' and 'NQ', and its output is 'Q'. The 'S' input is connected to a switch labeled 'RS'. The outputs 'NQ' and 'Q' are connected to red LEDs. The timing diagram at the bottom shows the signal levels for 'S' and 'Q1'. The 'S' signal is a square wave. The 'Q1' signal shows a series of high-frequency oscillations (glitches) that occur whenever the 'S' signal transitions from high to low, indicating a race condition between the two NOR gates.

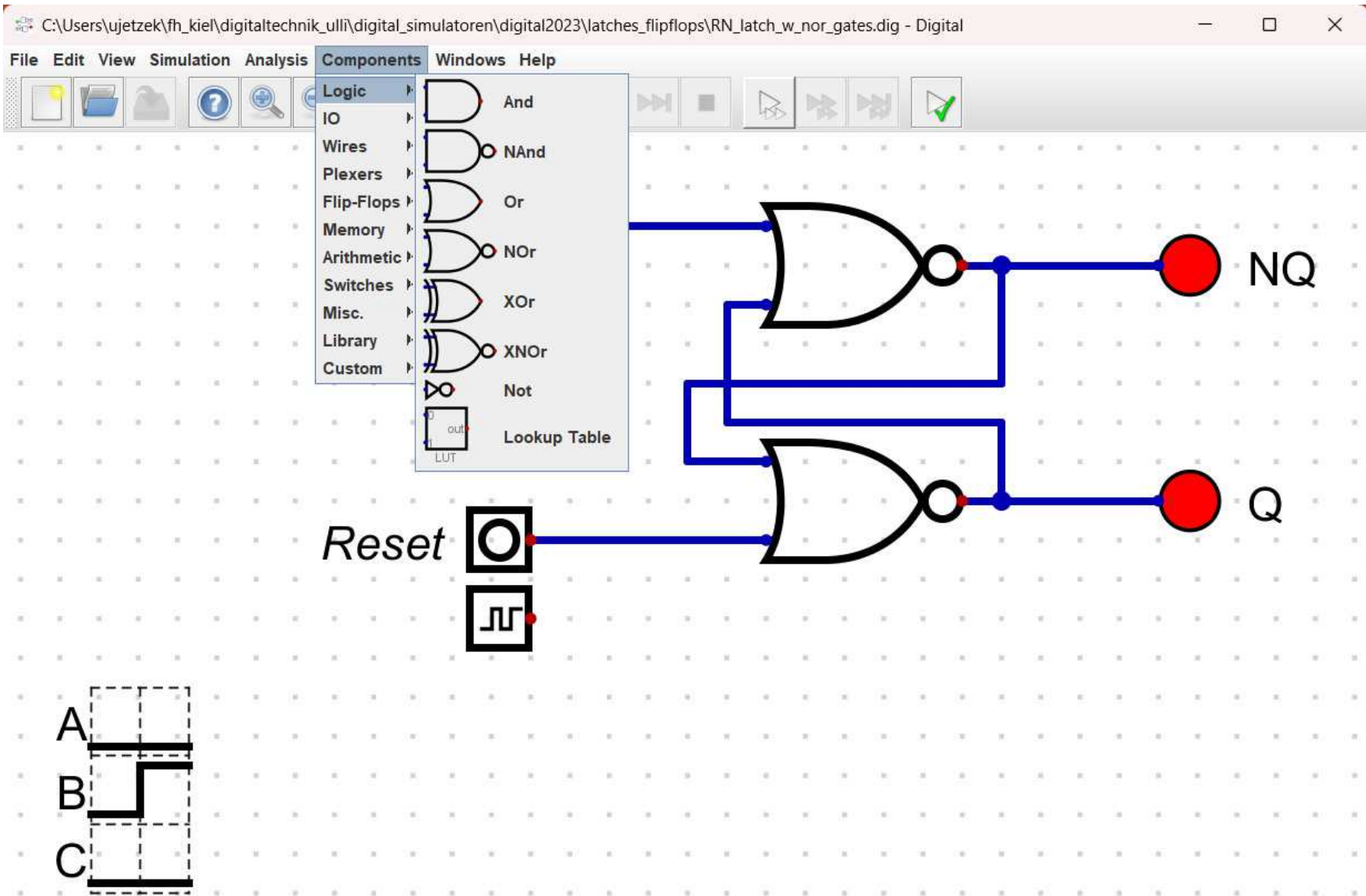
RS_latch_nor.dsim RS_latch_nor_oscillating.dsim

Digital Simulator v5.57

- + very intuitive and easy to use!
- + wiring extremely quick and easy!
- + supports continuous time input signals
- + allows to simulate oscillating systems
- + well suited for education, in particular to explain / learn digital logic!
- time direction from right to left (contrary to ,normal` usage)
- simulator does not contain any standard IC elements → not suited to bring any simulation into a ,real` design
- simulator not supported any more

„Digital“

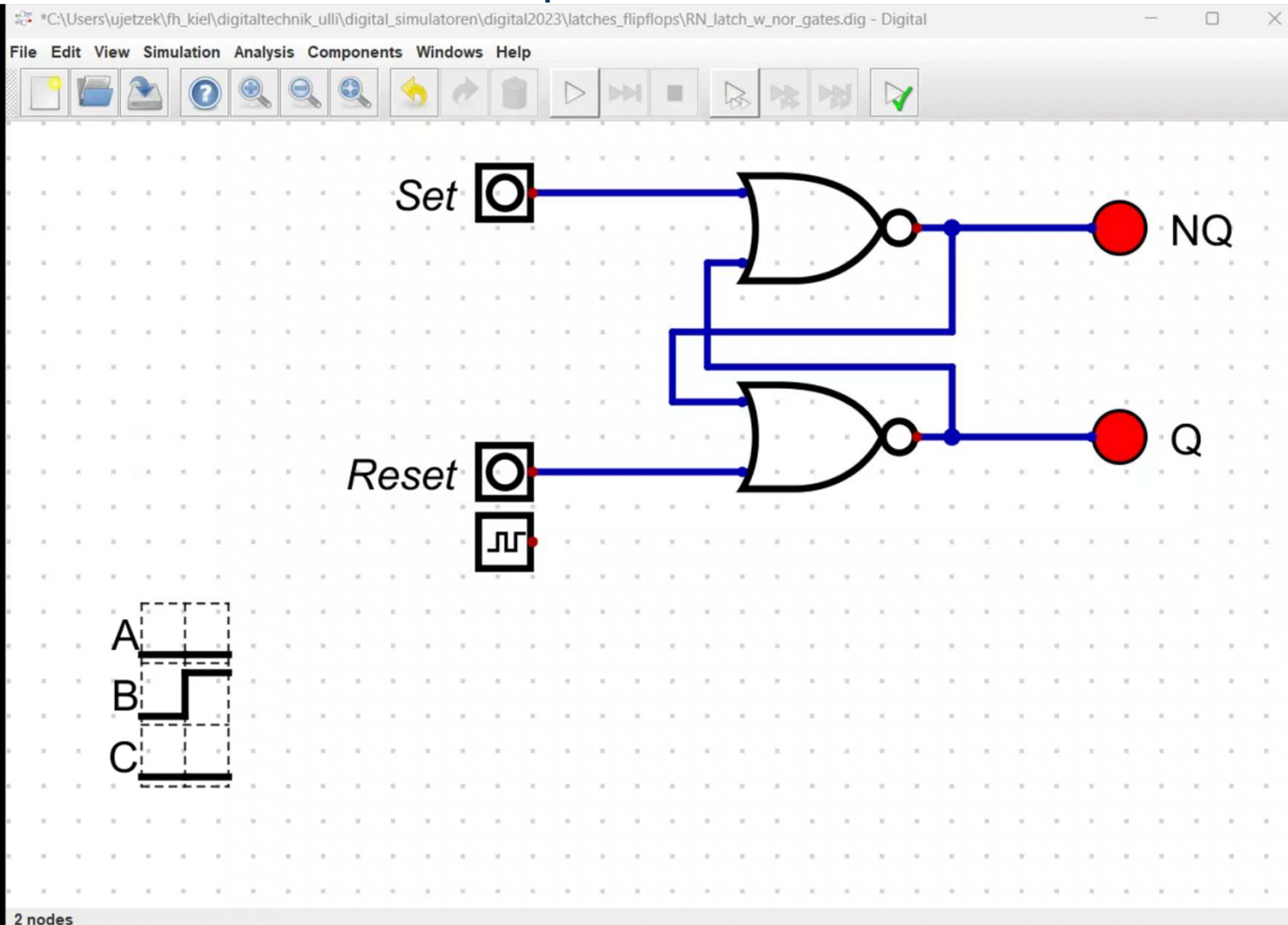
- Created by Helmut Neemann
- Available on Github: <https://github.com/hneemann/Digital>



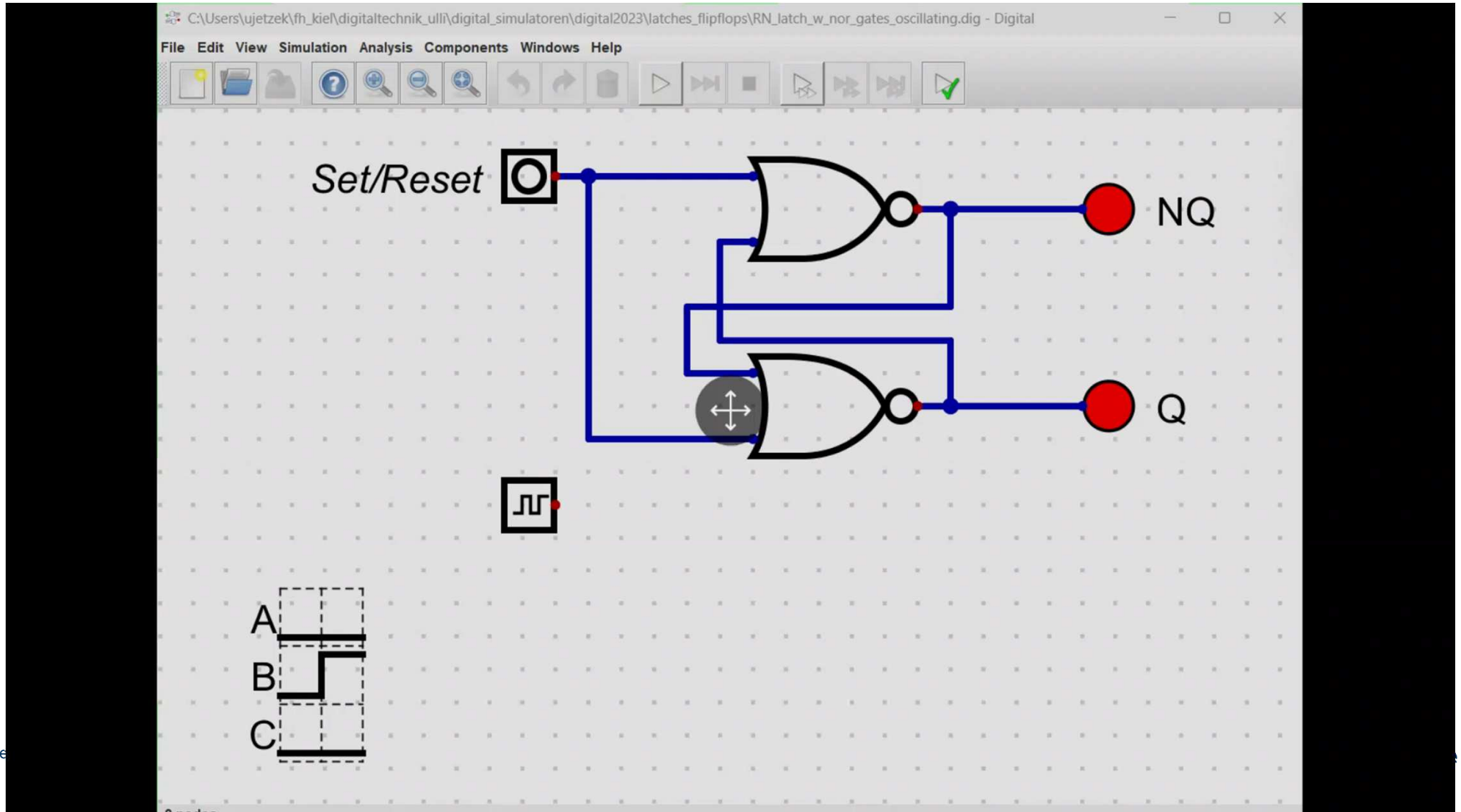
„Digital“

- works with **drop-down** menus
- Wiring not so intuitive – takes more time to get into it ...
- Does not allow continuous input signals, rather works with ‚implicit‘ clocked time base.
- Is multi-lingual (German, English, Spanish, French, Italian, ...)
- English or German logic element notation possible

„Digital“ – RS Latch – normal operation



„Digital“ – oscillating RS Latch (race condition)



„Digital“

- + Supports logic analysis of combinatorial logic, may
 - Generate Boolean function of existing circuit
 - Truth table and K-map
- + Also supports standard IC, like 74xx series
- + Supports export of standard-IC-based circuits to VHDL and Verilog!
- + more useful to bring designs forward to real implementation
- Not so intuitive – needs to more time to get into it
- Does not support continuous input signals (implicit clock base)
- Does not allow simulation of oscillating circuits (however: Warning occurs!)

„Circuitverse“

- Is a digital simulation internet platform
- Available under: <https://circuitverse.org/>
- created and maintained by an Indian student-driven organisation,
- Is an open source project available on github: <https://github.com/CircuitVerse>
- Intended as platform for teachers and students to dive into the world of digital circuits

„Circuitverse“ - dashboard



Simulator

Getting Started ▾

Features

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Ulrich ...

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dig_v3_aufgabe1_new

Limited access



Launch

View

More

dig_v3_aufgabe4_reaktionszeit

Limited access



Launch

View

More

Aufgabe 2

Public



Launch

View

More

„Circuitverse“

- Offers the possibility to create **student groups**, e.g. different lab groups
- **„Mentor“ and „Member“ roles** available
- Possibility to **post specific assignments** with deadlines.
- **Grading possibility** exists
- Mentor may online observe simulation design progress for a specific class (only requirement: students need to frequently save their projects).
- Collaboration on same project possible by different persons

Ulrich Jetzek · x | Ulrich Jetzek · x | CircuitVerse · x | Ulrich Jetzek · x | CircuitVerse · x | CircuitVerse · x | (32) CircuitVer · x | +

circuitverse.org/simulator/edit/nor_latch_with_single_input

TEO - Banking App | Mensa - Speiseplan | FH Kiel - FB IuE | QIS FH Kiel | UC Davis Canvas Di... | TYPO3 FH Kiel | my.ucdavis.edu | Academic Dates an... | >> | Alle Lesezeichen

CircuitVerse Project Circuit Tools Help NOR_latch_with_single_input Ulrich Jetzek

Main x +

CIRCUIT ELEMENTS

Search..

- Input
- Output
- Gates
- Decoders & Plexers
- Sequential Elements
- Annotation
- Misc

TESTBENCH

0:1
1:2

TIMING DIAGRAM

1 cycle = 1000 Units Utilization: 20 Units (2%) Recommended Units: 60

Time	RS	Q	NQ
477	0	0	1
478	0	0	1
479	0	0	1
480	1	0	1
481	1	0	1
482	1	0	1
483	1	0	1
484	1	0	1
485	1	0	1
486	1	0	1
487	1	0	1
488	1	0	1
489	1	0	1
490	1	0	1
491	1	0	1
492	1	0	1
493	1	0	1
494	1	0	1
495	1	0	1
496	1	0	1
497	1	0	1
498	1	0	1
499	1	0	1
500	1	0	1

RS 0 Q 0 NQ 1

Q

Circuit:
Main

Clock Time (ms):
- 500 +

Clock Enabled:

Lite Mode:

Edit Layout

Delete Circuit

Screen Recorder

00:00:00 | Initiatin

ch_with_single_inp

Kiel

„Circuitverse“ – summary

- + Digital simulation platform intended for online education
- + Provides very good feature set for online classes:
 - student groups
 - mentor- and member role
 - Collaboration possibilities
 - monitoring design progress of students
 - posting assignments
 - Grading possibilities
- + Was of great help during Covid-times!
- Race condition/oscillating circuit not visible in simulation nor blocked by simulator.
- Does not provide standard elements (e.g. 74xx ICs), very limited support for implementation of circuits / student projects.

Conclusion

- Presented digital simulators provide good features for digital circuit simulation!
- All of them are valuable tools for students to learn the fundamentals of digital system design
- „Digital simulator v5.57“ – most intuitive and easiest to handle.
- „Digital“ provides most support for implementation of digital circuits and additional analysing features (Boolean function generation, K-maps, ...).
- „Circuitverse“ great internet platform – good for online education formats.

Thank you !
Any questions?