

# lab 04

## Seven-segment display

Digital design – laboratory exercises

assistant: Nejc Ilc

# Basics (1)

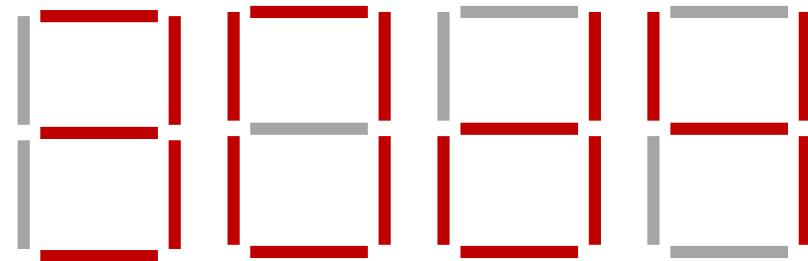
- Development board includes a display for eight digits (places). Each digit is displayed using eight segments.



0 1 2 ... A B C d e F

# Basics (2)

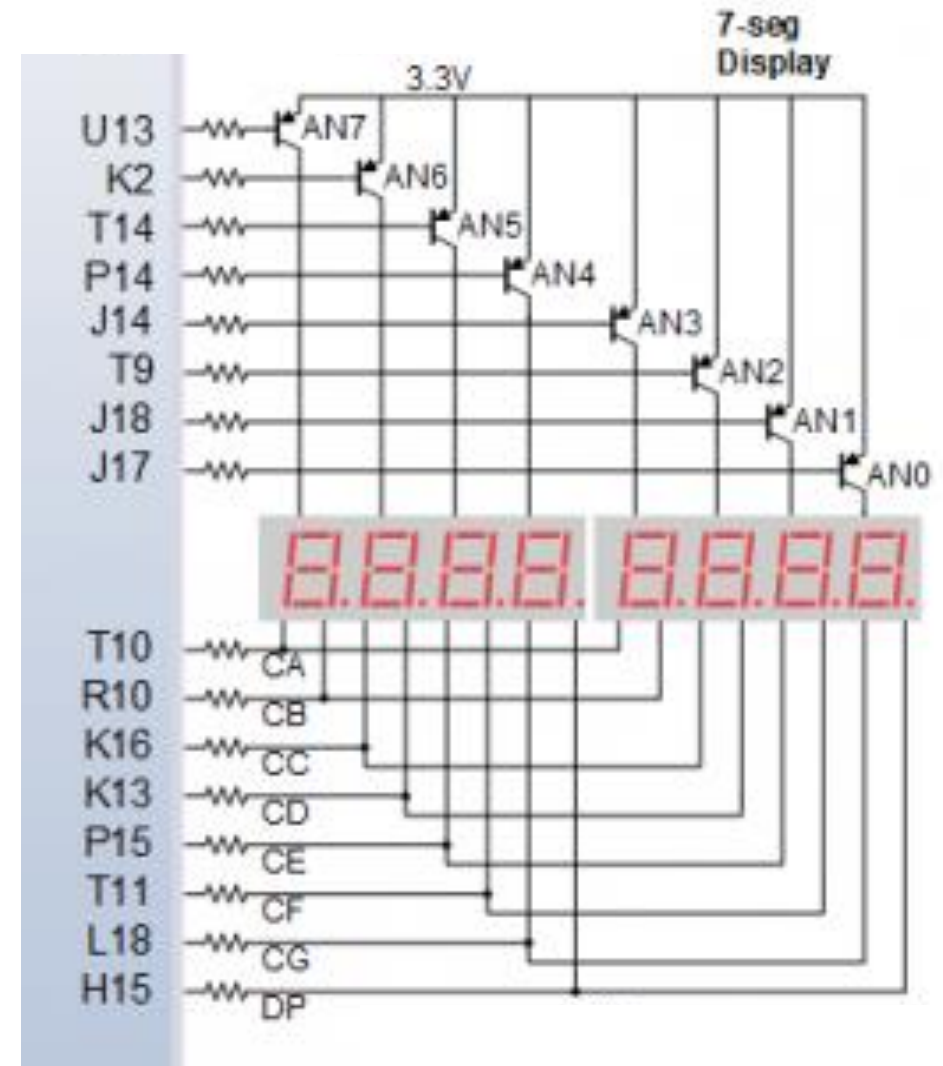
- Each digit is controlled by 8 signals: these are the LED cathodes. LED anodes share common signal for all segments of a digit.
- Each of eight digits has its own anode (AN0-AN7).
- Digits share a common set of eight cathodes (CA-CG + DP).
- Negative logic:
  - 0: a segment is enabled
  - 1: a segment is disabled



number 0x30d4 = 12500

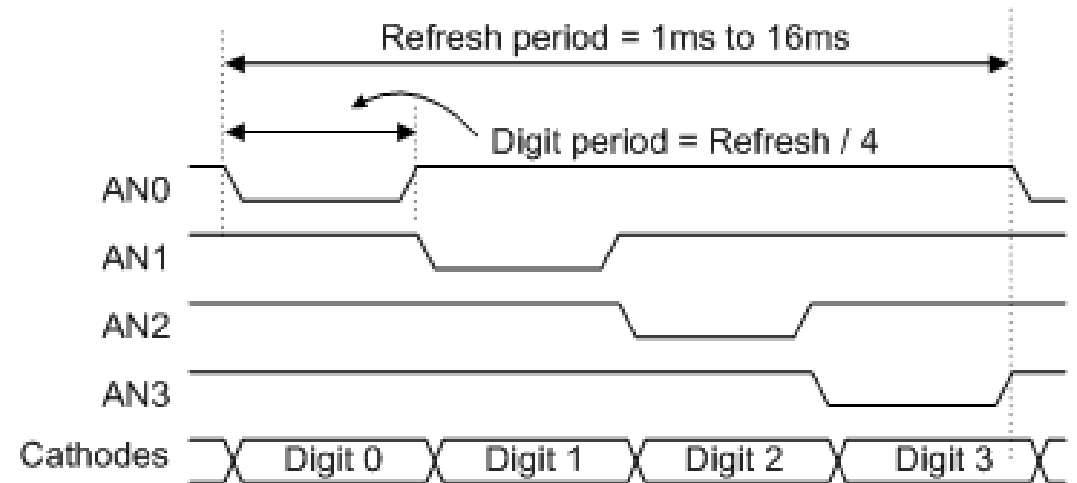
# Basics (3)

- Ideally, we should have eight signals for each of the eight digits to activate the segments (64 wires total). Unfortunately, this is wasteful.
- Solution: time-division multiplexing
  - 8 signals per digit for segment selection → cathodes
  - 8 signals for digit selection → anodes

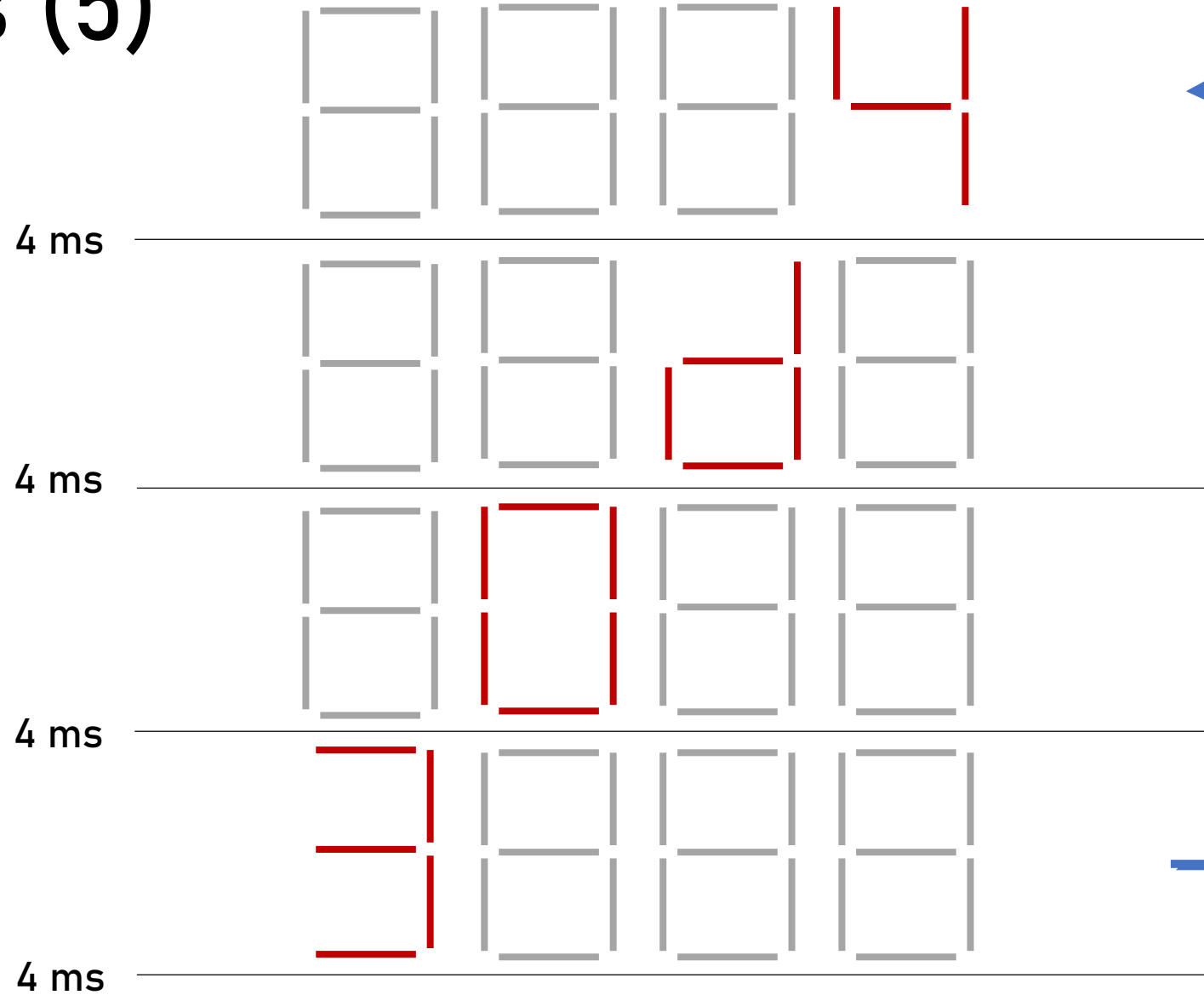


# Basics (4)

- Time-division multiplexing: each digit is refreshed at regular intervals. If the time interval is short enough, the human eye cannot detect flickering.
- Refresh rate  $\sim 60$  Hz ( $\sim 16$  ms period):
  - 8 digits: 2 ms/digit
  - 4 digits: 4 ms/digit
- We select a digit with an assertion of the corresponding anode (AN0-AN7).



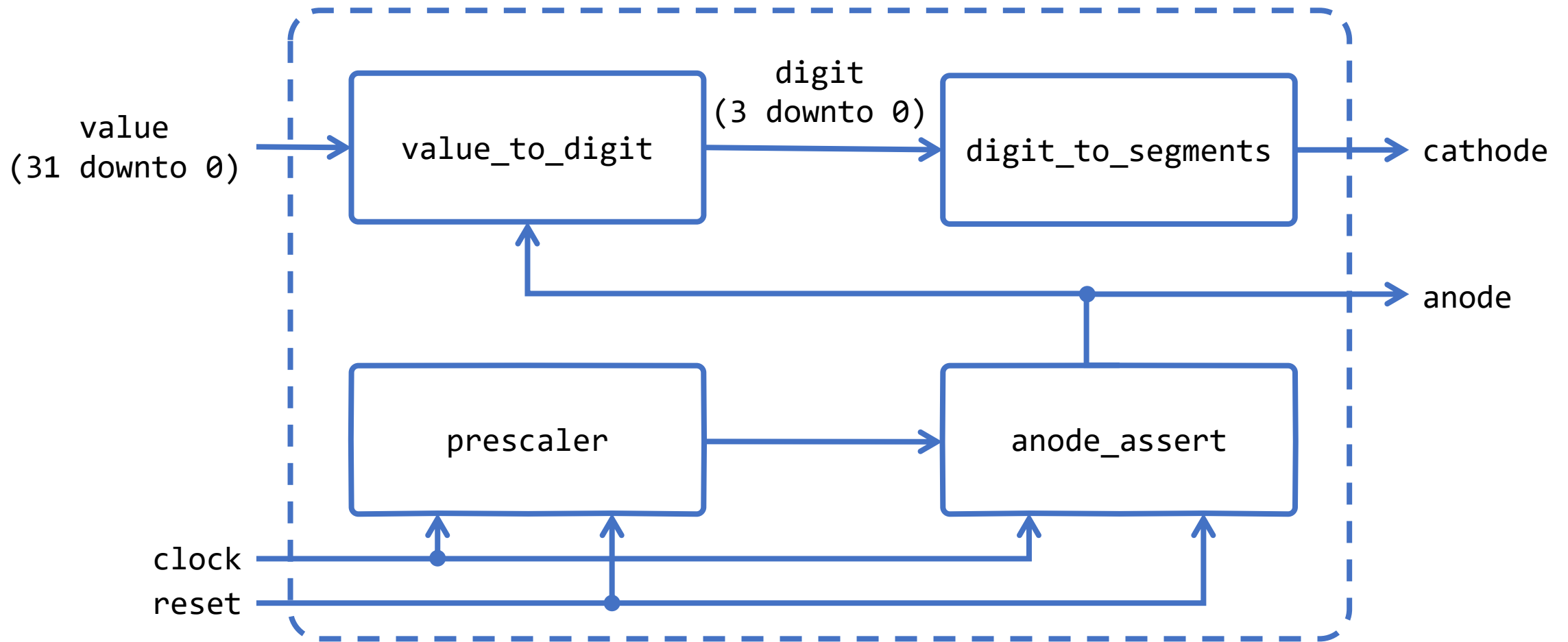
# Basics (5)



# seven\_seg\_display: submodules

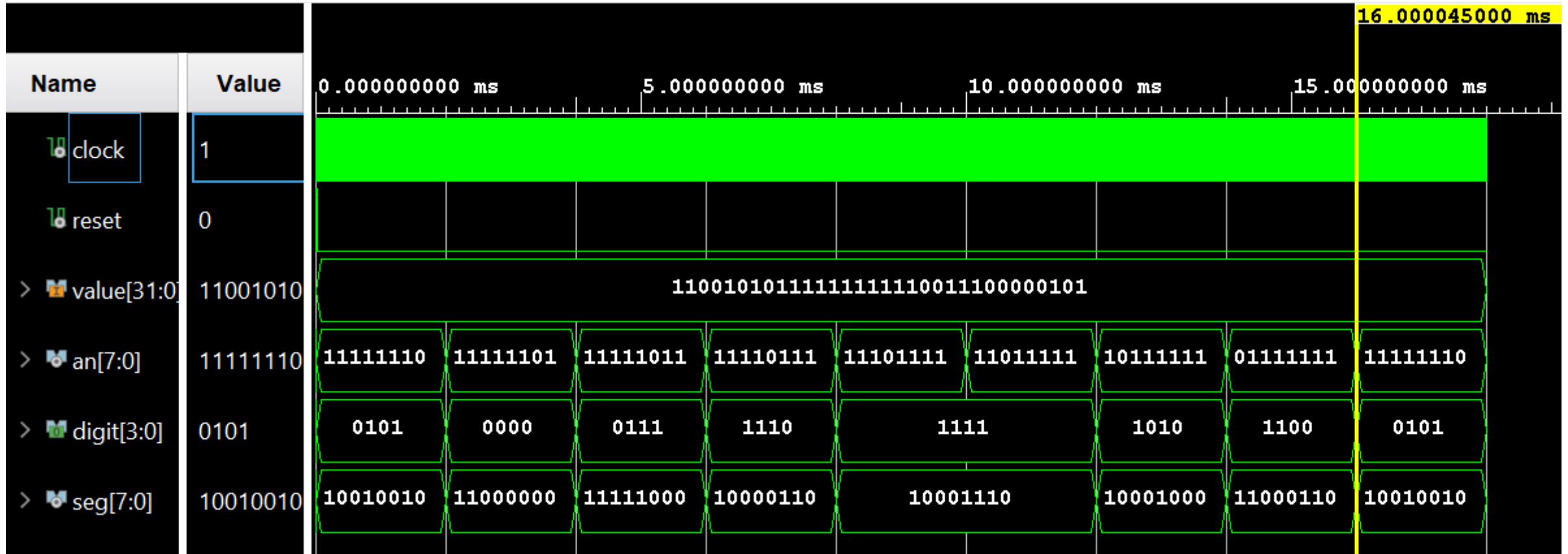
- prescaler
  - target frequency 500 Hz (why?)
- anode\_assert
  - periodic assertion of an anode of each digit
  - $1\dots110 \rightarrow 1\dots101 \rightarrow 1\dots011 \rightarrow \dots \rightarrow 01\dots111$
- value\_to\_digit
  - considering the asserted anode, choose 4 bits out of 32 (we have 32-bit counter value) to display one digit
- digit\_to\_segments
  - map 4-bit number to segments (activate cathodes)

# seven\_seg\_display: scheme





# Simulation



# Challenge

In lab03 we created a counter that in/decrement every second. Now, display the counter value on a seven-segment display.

- counter value is 32-bit
- use switches to control the counter direction (up, down, none)
- use all eight digits of the display