DRAM Simulator

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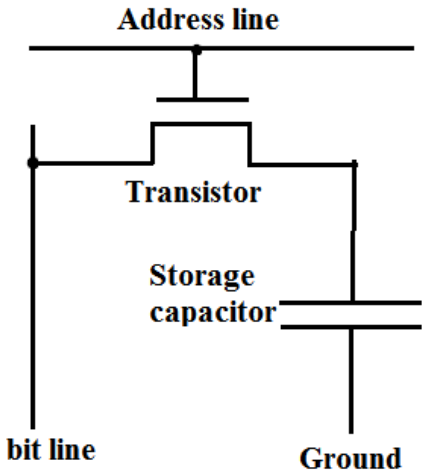
Outline

- Introduction
- DRAM controller
- Simplified DRAM Simulator
  - Timing Specification
  - Waveform

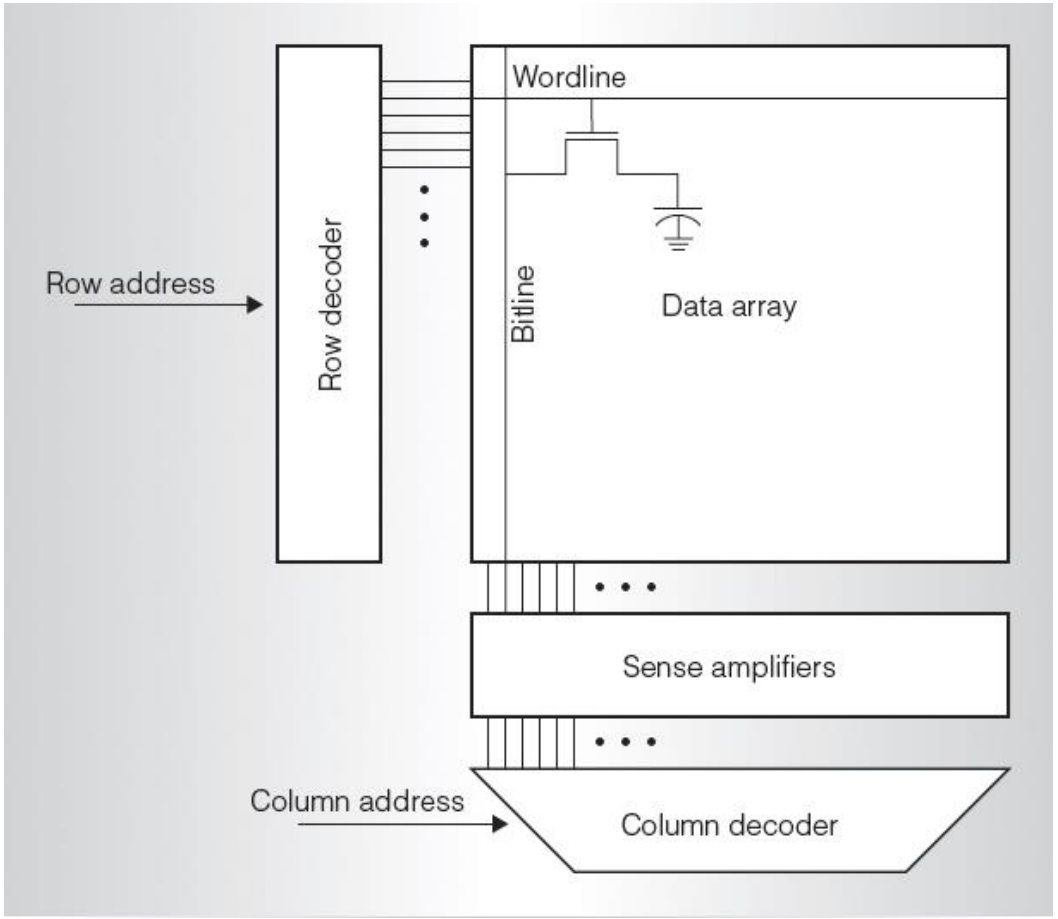
Introduction

- Dynamic random-access memory (dynamic RAM or DRAM) is a type of random-access semiconductor memory.
- Consisting only a capacitor and a transistor for each bit of data.
- The electric charge on the capacitors slowly leaks off.
  - refresh!



Introduction

- Three Basic Operations
  - Row Access
  - Column Access
  - Pre-charge

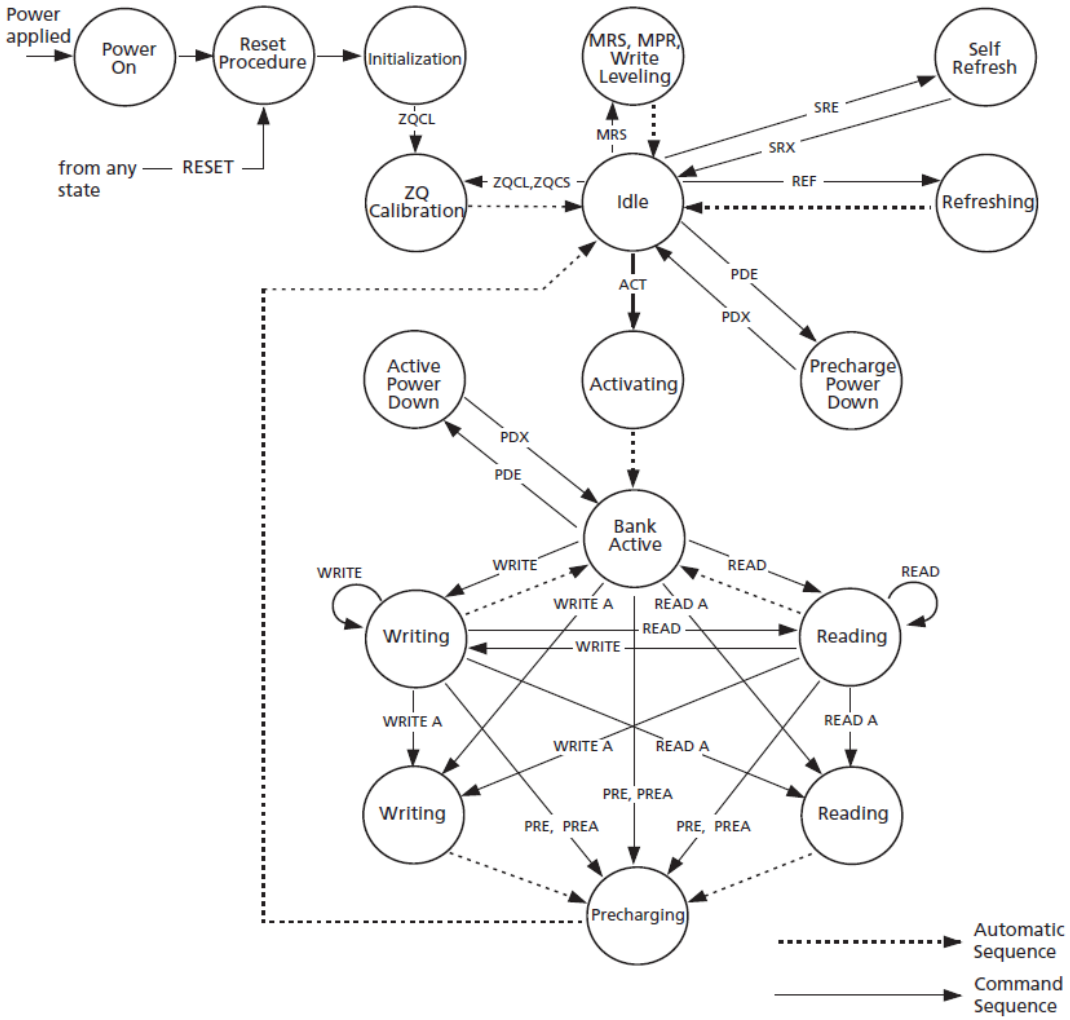


DRAM controller

- Ensure correct operation of DRAM
  - Address Mapping, refresh and timing
- Translate request to DRAM command sequences
- Buffer and schedule requests to improve performance
  - Reordering, row-buffer, bank, rank, bus management
- Manage power consumption and thermals in DRAM
  - Turn off/on DRAM chips, manage power modes

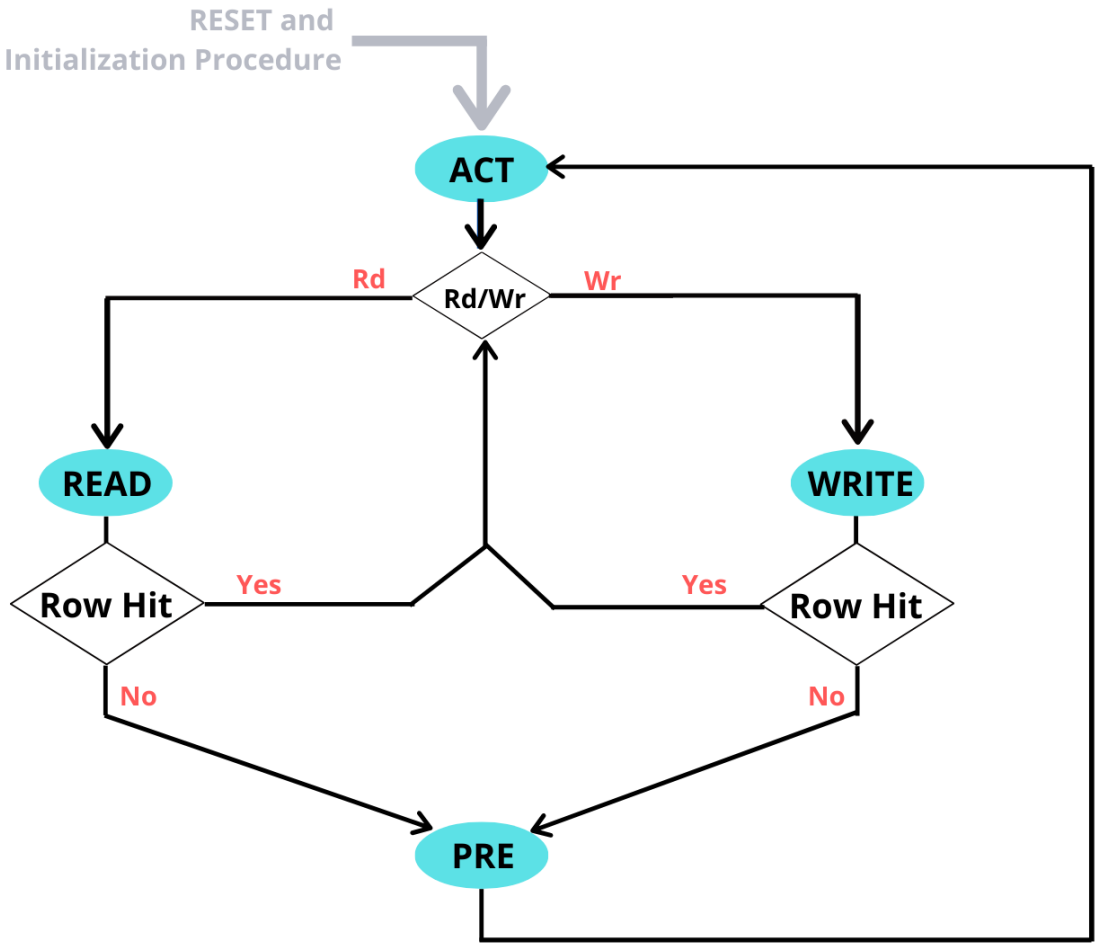
DRAM controller

State diagram



Simplified DRAM Simulator

- Act : Activate row
  - RASn = low
  - CASn = high
  - WEn = 4'hf
- READ: Read operation and access column address
  - RASn = high
  - CASn = low
  - WEn = 4'hf
- WRITE: Write operation and access column address
  - RASn = high
  - CASn = low
  - WEn = 4'h0 (for a word)
- PRE : Pre-charge
  - RASn = low
  - CASn = high
  - WEn = 4'h0
  - The address should be the same as the one that activated last time.

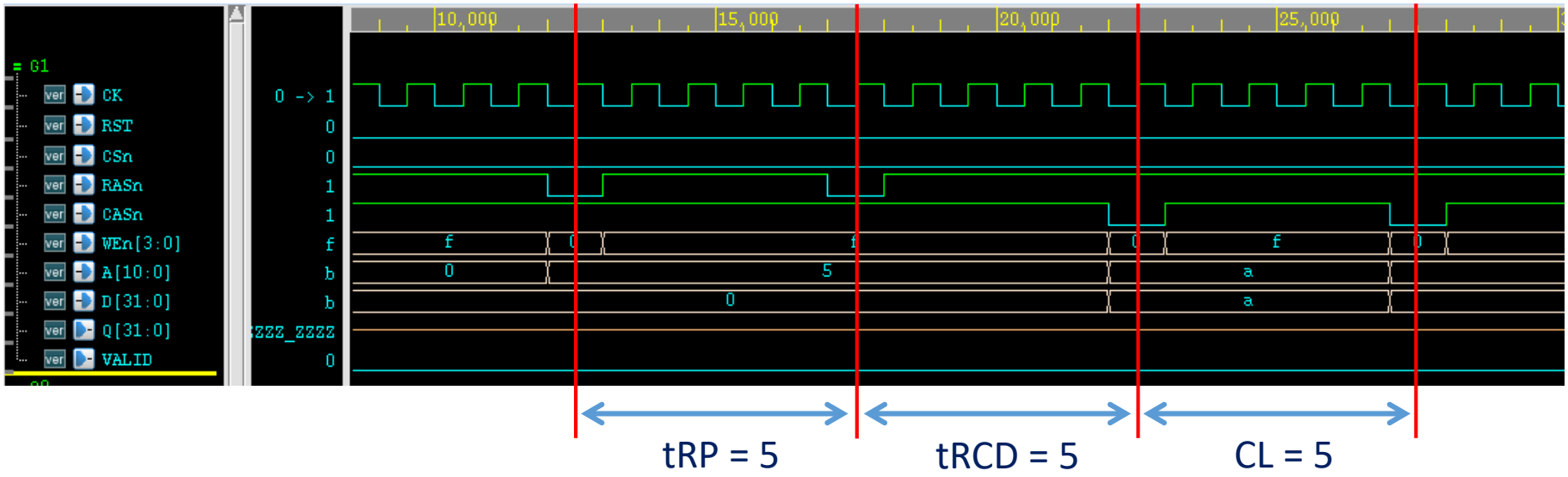


Simplified DRAM Simulator

DRAM	System signals			
	CK	input	1	System clock
	RST	input	1	System reset (active high)
	Memory ports			
	CSn	input	1	DRAM Chip Select (active low)
	WEn	input	4	DRAM Write Enable (active low)
	RASn	input	1	DRAM Row Access Strobe (active low)
	CASn	input	1	DRAM Column Access Strobe (active low)
	A	input	11	DRAM Address input
	D	input	32	DRAM data input
	Q	output	32	DRAM data output
	VALID	output	1	DRAM data output valid
	Memory space			
	Memory_byte0	reg	8	Size: [0:2097151]
	Memory_byte1	reg	8	Size: [0:2097151]
	Memory_byte2	reg	8	Size: [0:2097151]
	Memory_byte3	reg	8	Size: [0:2097151]

★ Row address is 11-bit and column address is 10-bit

Timing Specification



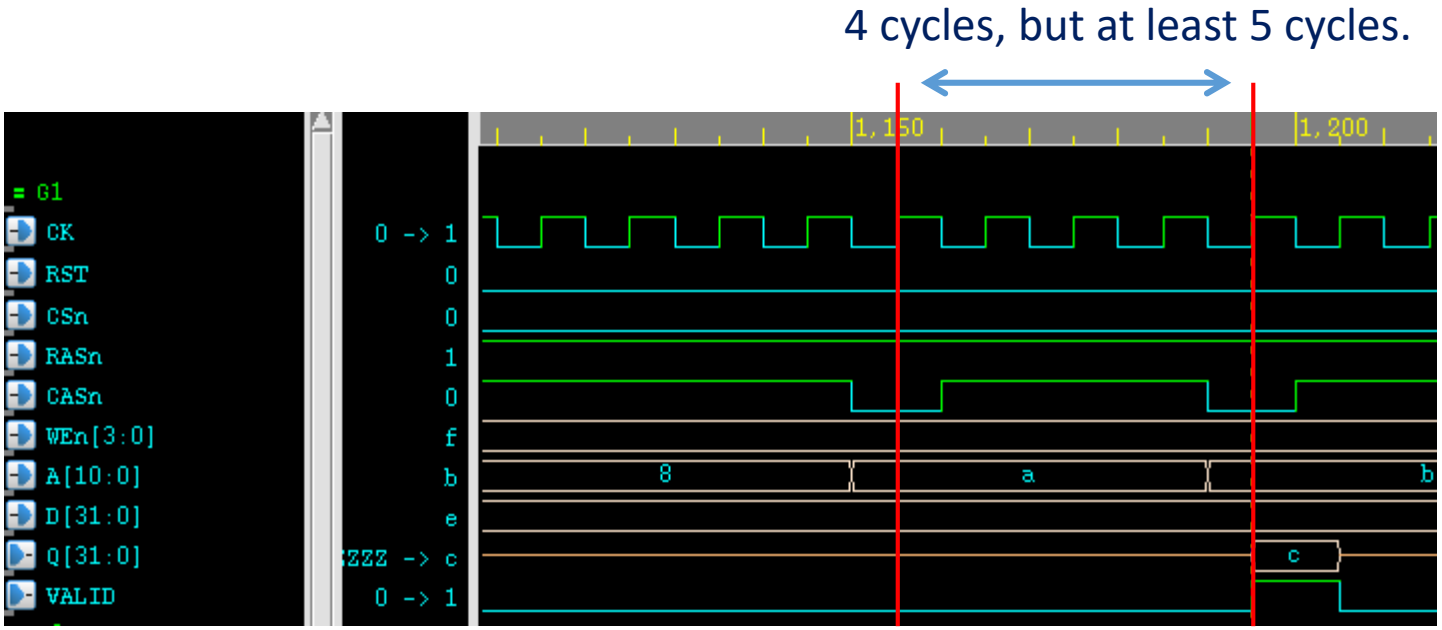
tRP -Precharge Time
Delay time until the next RAS is asserted

tRCD -Row Address to Column Address Delay
Active to Read/Write command time

CL -CAS Latency
Delay time between the READ command and the moment data is available

Timing Specification

- If the transition violates the timing specification, it will show error or terminates the execution .

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ncsim: *E,ASRTST (./DRAM.sv,149): (time 1195 NS) Assertion test.M1.CL_check has failed

 *** CL Violation ! CASn should have more than 5 cycles interval ***
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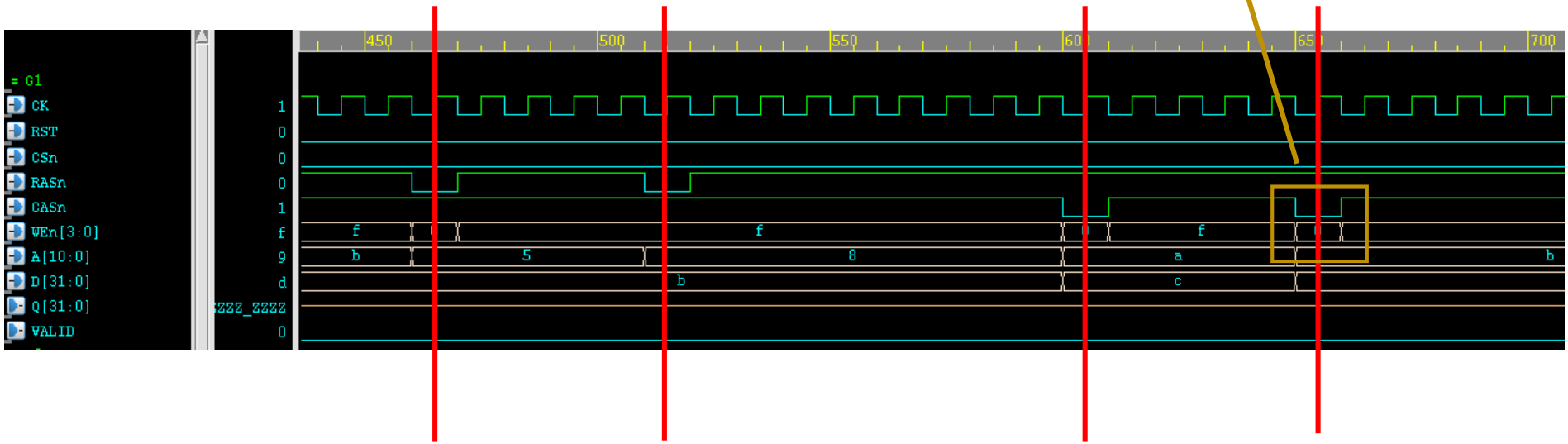
Waveform

- RAS → Set Row
  - A should be ready
- CAS → Set Column
  - READ : A and WEn should be ready
  - WRITE : A, WEn and D should be ready

Read/Write command Registration

READ if WEn = 4'hf

WRITE if WEn != 4'hf



Pre-charge
row = 5

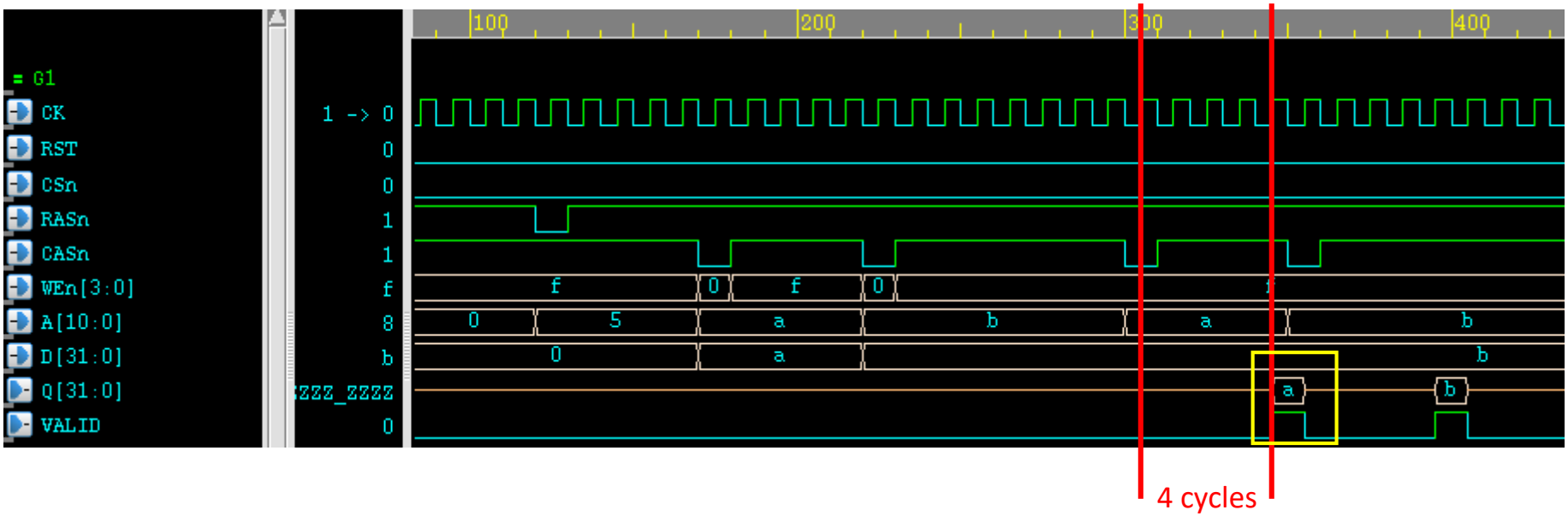
Activate
row = 8

Write
column = a

Write
column = b

Waveform

- Read operation
  - Data will output with a valid signal



Thanks for listening