EECS 151/251A
Discussion 12

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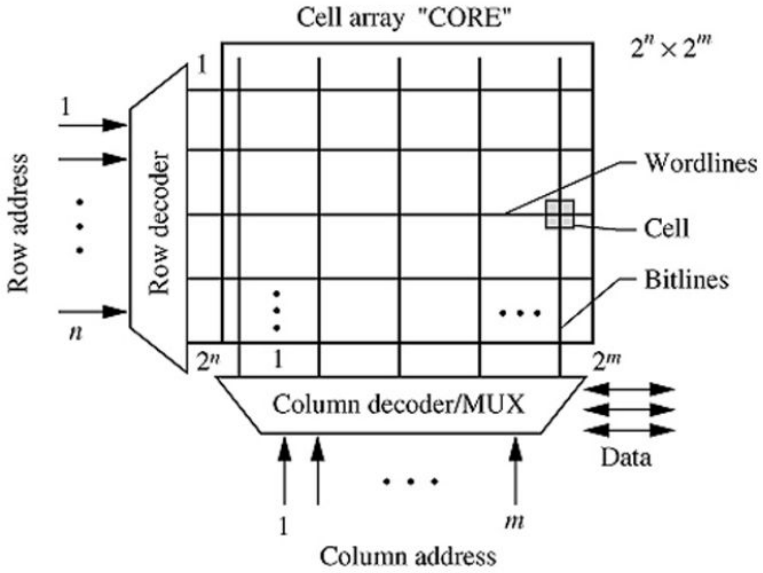
Agenda

- SRAMs
  - Architecture
  - 6T SRAM Read
  - 6T SRAM Write
  - Multi-Voltage SRAM
- Memory decoding
  - Design example

SRAMs

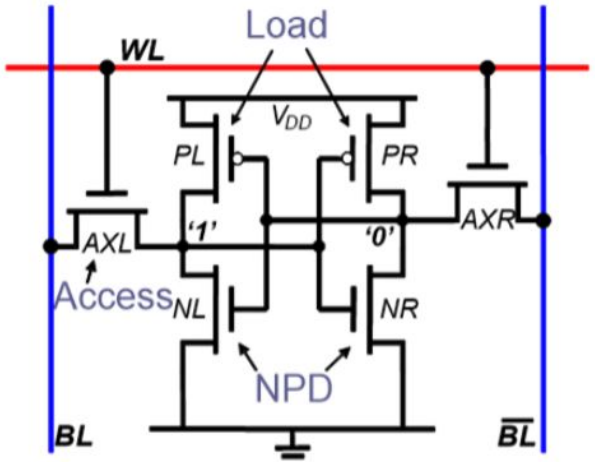
SRAM Architecture

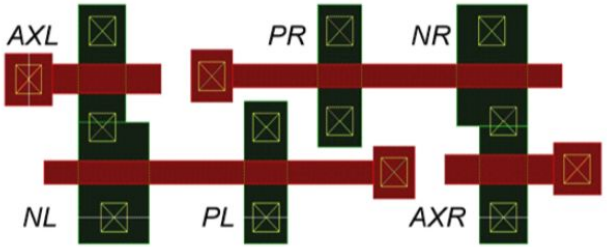
- Grid of SRAM bitcells:
  - width = word size
  - height = # of words
- **Bitlines** (vertical) are shared across cells in a column
  - Long wires with a large capacitive load (drains of access transistors, read/write circuits)
- **Wordlines** (horizontal) are shared across cells in a row
  - Also long with large capacitive load (gates of access transistors)
- Peripheral circuitry (bitline drivers, sense amp, decoders)
  - Need to reduce the total number of pins, N+M address lines for 2^(N+M)
  - Ex: if N+M=20 --> 2^20 = 1 Mb



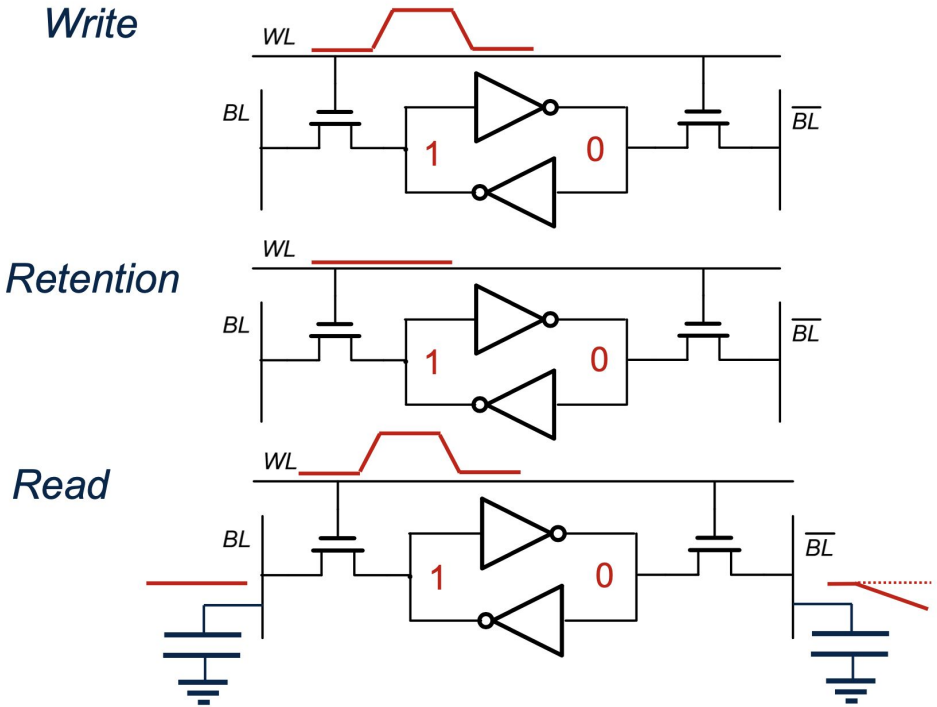
The 6T SRAM Cell

- Inverters (PL NL and PR NR)
  - in positive feedback form the memory element (like a latch!)
- AXL and AXR are the access transistors
  - Allow the bitlines to access the memory nodes (Q, Qbar) when WL = 1
- Only 1 WL in an SRAM array is active at a time
  - Addresses an entire row of SRAM cells
- Bitlines are controlled differently for read and write



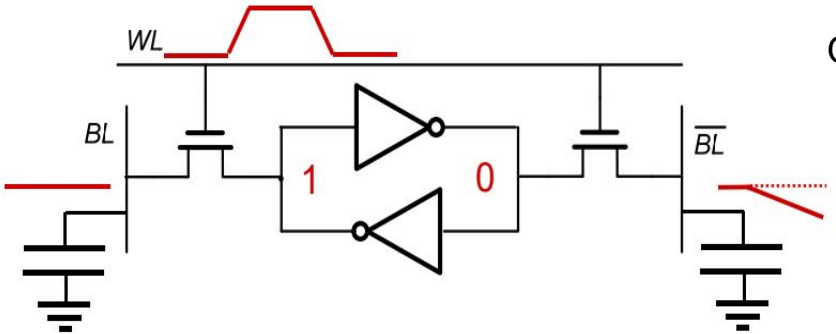


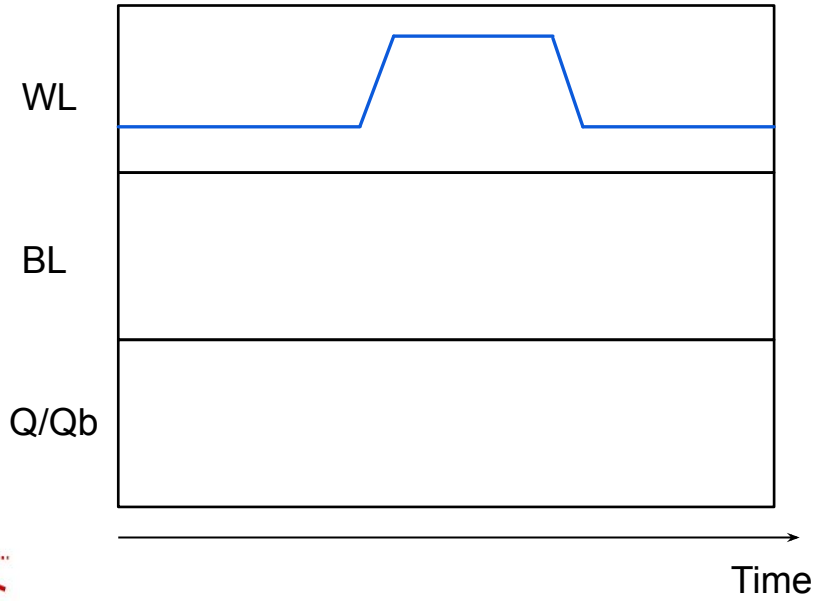
6T SRAM Cell: 3 Modes of Operation



SRAM Read Operation

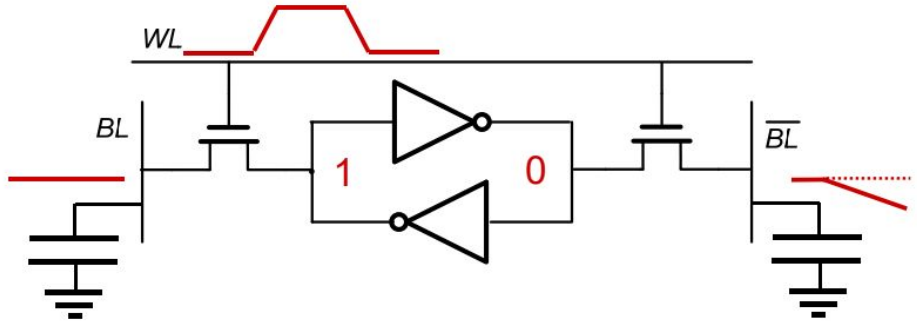
- Procedure:
  - Precharge BL and BLbar to VDD
  - Raise WL
  - Sense dip on one bitline with sense amp
  - Lower WL
  - Discharge bitlines

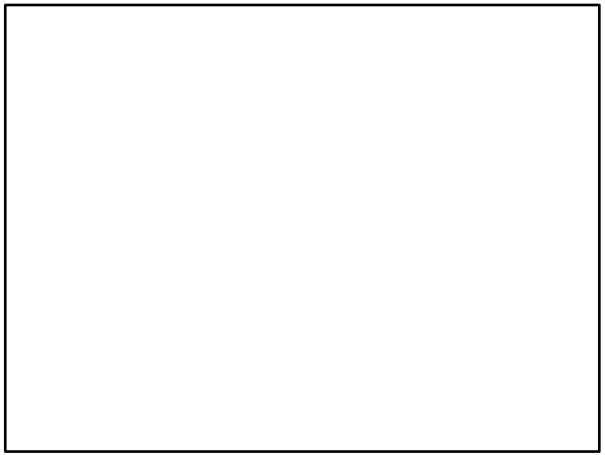




SRAM Read Stability

- Read stability = reading doesn't corrupt the value stored in Q and Qbar
  a. The access transistor shouldn't overpower the node storing a '0' and flip its state
  b. Sizing: make the latch NMOS stronger than the access transistor = ($W_n > W_{access}$)



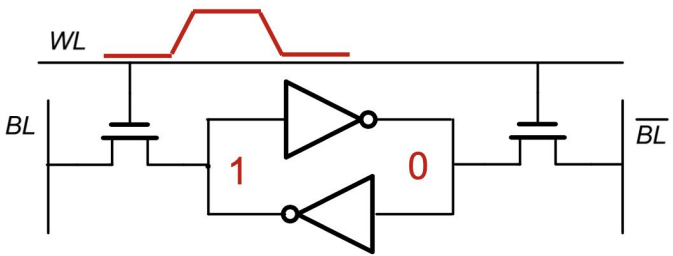


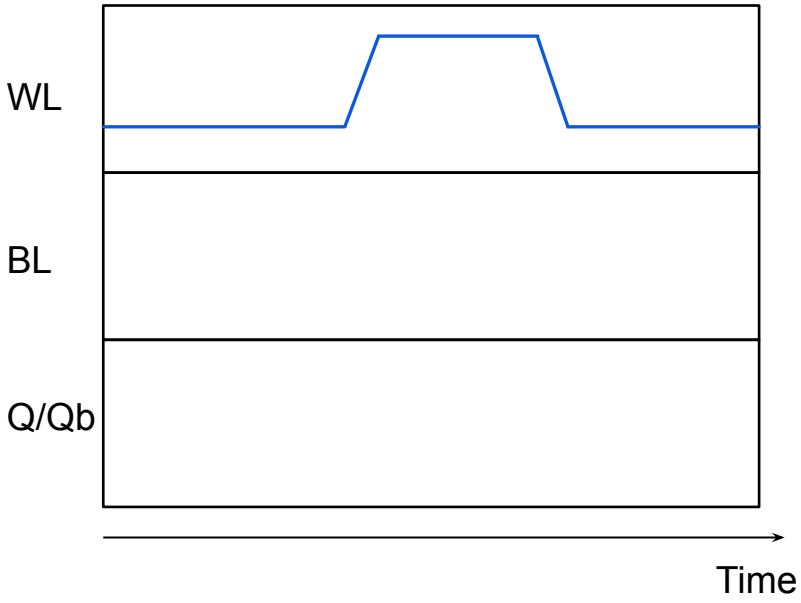
Equivalent Circuit

Read SNM

SRAM Write Operation

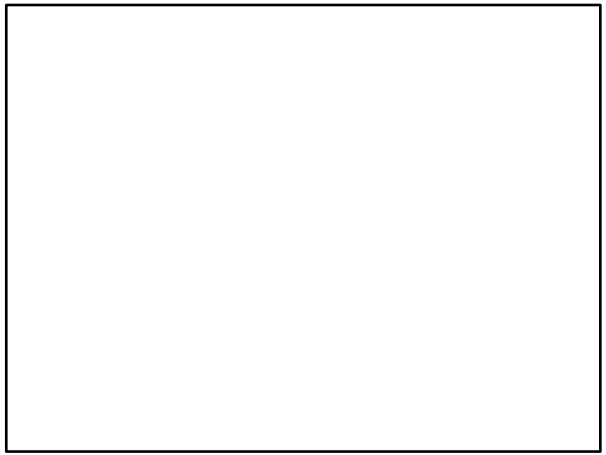
- Procedure:
  - Drive BL and BLbar with data to write
  - Raise WL
  - Wait some amount of time (write time)
  - Lower WL
  - Discharge bitlines



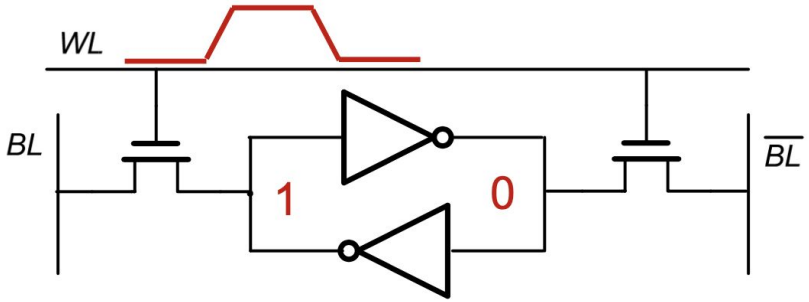


SRAM Write

- Write-ability = the cell's memory value can be changed
  a. Access transistor must overpower latch
  b. Assuming the cell is read stable ($W_n > W_{access}$), the node with '0' can't be overpowered => *so we must overpower PMOS* ($W_{access} > W_p$) and override the '1' node



Equivalent Circuit



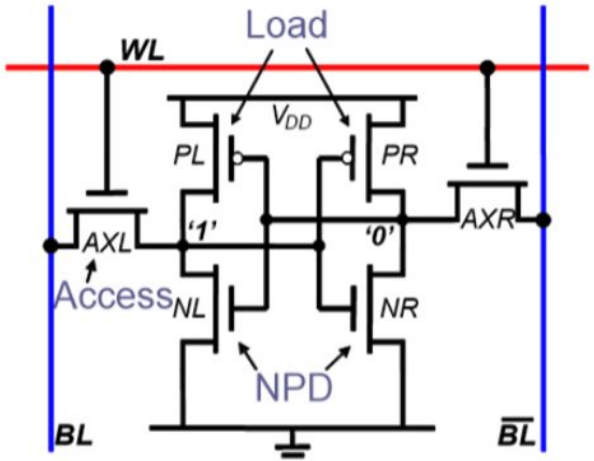
Write SNM

Conflicts between read and write

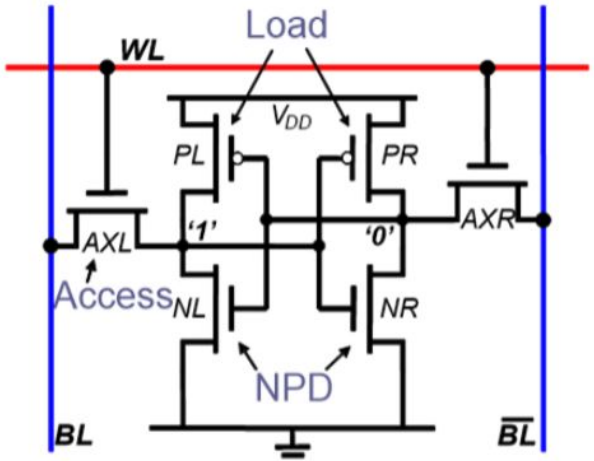
Size 6T the SRAM cell for optimized read and write operation separately:

Small

Large



Read optimized



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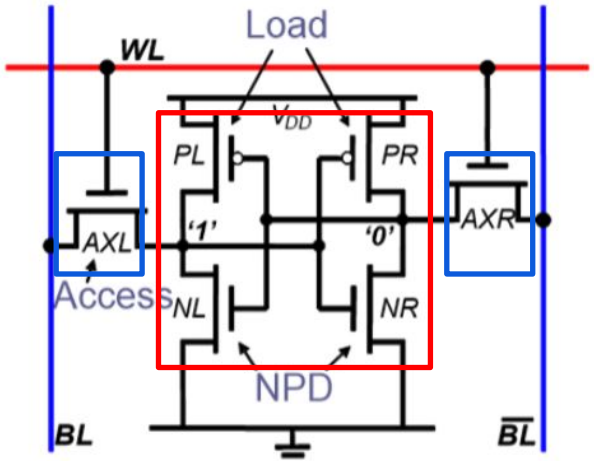
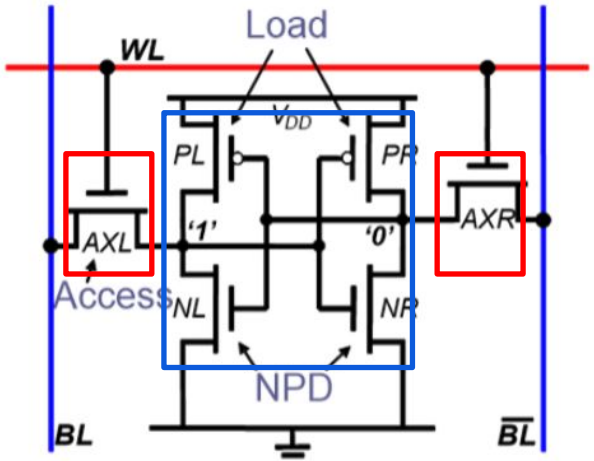


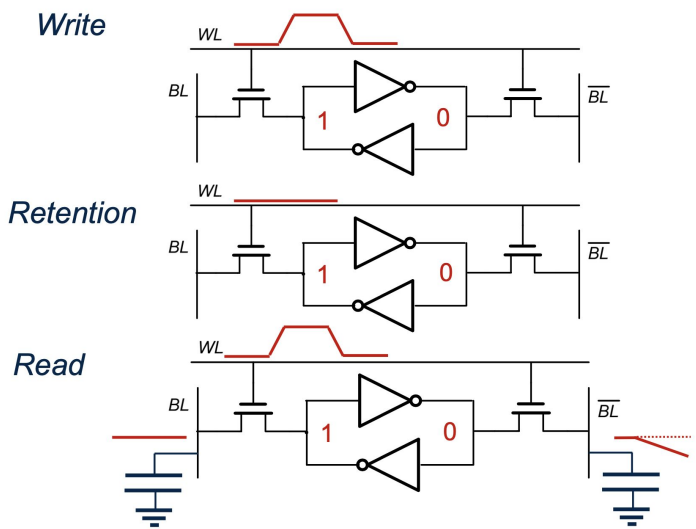
Read optimized



Write optimized

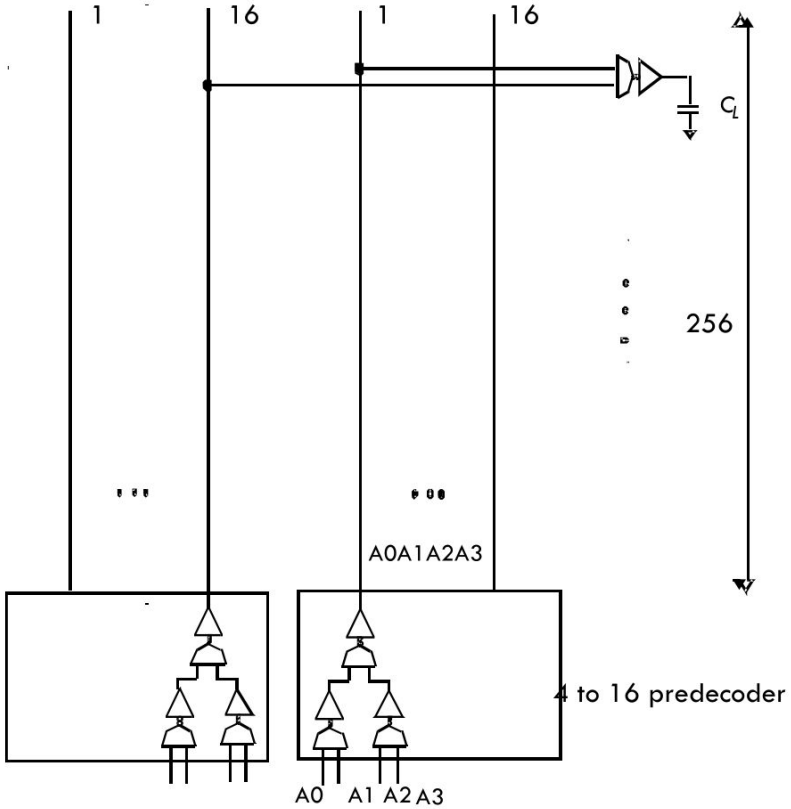
Multi-Voltage SRAM

You have 3 high voltage levels to choose: 0.9V, 1.0V(ref), 1.1V;
3 low voltages: -0.1V, 0V(ref), 0.1V
Which voltage is preferred?



	Readability	Read Stability	Writability
WL			
BL			
VDD			
GND			

Memory Decoders

2-Stage Decoding

- Problem: each distinct address => 1 WL
  - Binary-to-thermometer conversion!
  - Naive method: each WL has its own NAND + inverter tree (a lot of load & logic!)
- 2-stage decoding: predecoders and final decoders
  - Decode some bits first, then the rest (MSB/LSB doesn't matter)
  - Larger predecode is better (this is just a path delay w/ branching problem)