Types of RAM

- Static RAM (SRAM)
- Dynamic RAM (DRAM)
- Other esoteric types
SRAM

- Static RAM
- Basic cell is essentially a D latch
- Less dense (6-8 transistors per cell)
- Commonly used for MCU main memory, small buffers, CPU caches, etc
- Holds data indefinitely as long as power is applied
6T SRAM

- 4 NMOS, 2 PMOS per unit cell
- Normally organized in 2D grid
- Differential bit lines + pwr run on metal
  - Single ended r/w is possible in theory, but much less robust so rarely used
- Perpendicular word lines on poly (+ metal)
6T SRAM schematic
XC2C32A SRAMv1x1 (6T)
XC2C32A SRAMv0x1 (6T)
XC2C32A SRAM WLs
XC2C32A SRAM BLs
RSA SecurID SRAM (6T)
STM32 SRAM (6T)
PIC32MX340F512H SRAM (6T)
PIC12F683 SRAM (6T)
Lithography-optimized 6T cell

- Re-layout of textbook 6T cell
  - Parallel lines are easy to manufacture
- Example from PIC32MZ2048ECH (130 nm)
4T SRAM

- 4 NMOS transistors, 2 resistors
  - The NMOS dual of the 6T CMOS cell
- Denser than 6T, doesn't need separate PMOS
- Harder to manufacture, often slower read times
- Not seen very often in modern processes
  - We've been trying to find an example in the wild for siliconpr0n and haven't seen any
Multi port RAM

- Allows multiple reads/writes to happen at once
- Several ways to do this
- Most straightforward: Extra access transistors
8T cells and more

- Many other cell designs exist
- Most are optimized for higher performance
  - Extra buffering on WLs for reads etc
  - Not seen too often outside high-end SoC/CPU
Dynamic RAM (DRAM)

- Basic cell is a capacitor and access transistor
- Very dense (1T/1C)
- Commonly used for PC main memory etc, very rarely used on-die (eDRAM)
- Charge leaks off cap in a few hundred ms, needs constant refreshing
DRAM operation

- **Read**
  - Precharge bit lines
  - Activate row
  - BLs for 0 bits go low, BLs for 1 bits stay highish
  - Read is destructive, cells are now all zero
DRAM operation

• **Write**
  - Activate row
  - Drive data onto BLs
  - Close row

• **Refresh**
  - Read and write same value
  - Refresh one row every few μs round-robin
DRAM example
In-class exercise

- Look at some examples of memory and figure out what they are
What's this?
2T EEPROM from XC2C32A

- Was initially thought to be NOR flash but closer inspection showed 2T cells, not 1T
What's this?
Mask ROM from RSA SecurID 600

- Appears to be NOR type using contacts
- (not fully dumped yet, some photos are blurry)
Find the memory (Z86L08)
What's this?
UV EPROM from Z86L08
What's this?
SRAM from Z86L08
What's this?
Mask ROM

• From counterfeit FT232RL
  - (Actual die is branded Supereal)
• Hard to tell exact layout from this magnification
What's this?
SRAM from Myricom PCI DMA
Questions?

- TA: Andrew Zonenberg <azonenberg@drawersteak.com>
- Image credit: Some images CC-BY from:
  - John McMaster <JohnDMcMaster@gmail.com>
  - ZeptoBars (http://www.zeptobars.ru)