Types of Main Memories

- The instructor thanks the authors for sharing the presentation

Semiconductor Memories

- Read Only Memory (ROM)
- Random Access Memory (RAM)

RAM

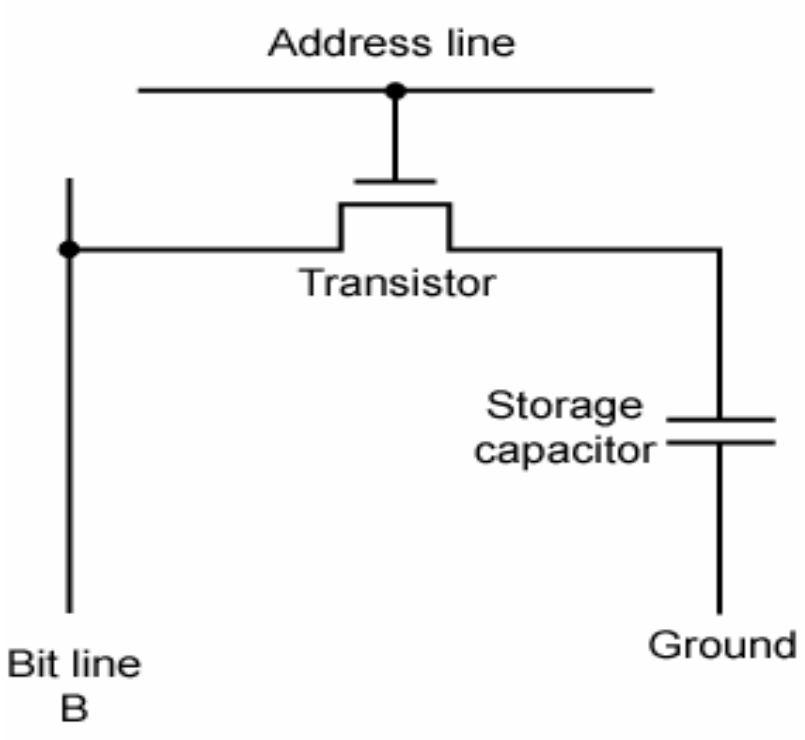
- Reading and writing is possible
- Both are accomplished using electrical signals.
- Volatile – so, used only as temporary storage.
- Two techologies
  - Static RAM (SRAM)
  - Dynamic RAM (DRAM)

Dynamic RAM

- Stores data as charge on capacitors
- If capacitor is charged
  - Data is 1
- Else
  - Data is 0.
- Needs refreshing cycle as capacitors have a tendency of discharging.
- The term *dynamic* refers to this tendency of the stored charge to leak away, even with power continuously applied.
- Volatile
- When read, data is lost. So, restoring need to be done.

Dynamic RAM

- DRAM cell
  - Consists of a transistor and a capacitor.
  - Transistor acts a switch
    - If transistor is closed
      - Allows current to flow
    - Else
      - No current flows



Dynamic RAM

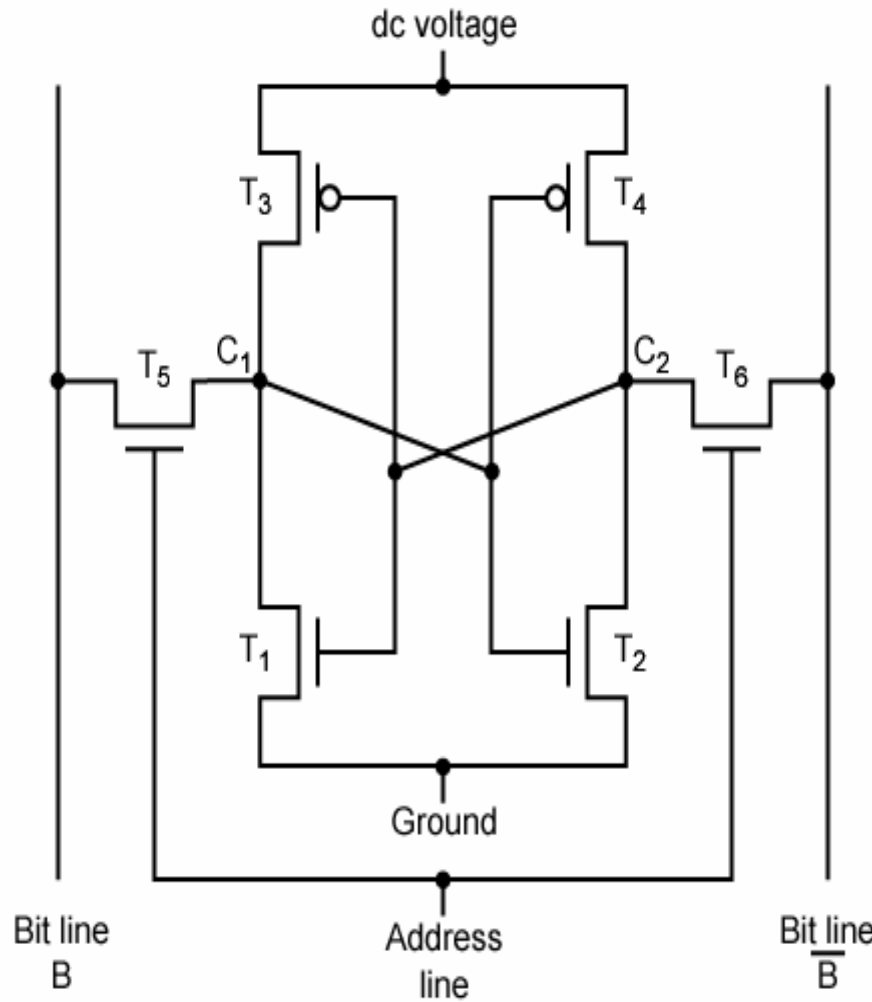
- Write
  - Voltage signal is applied to the bit line.
    - High voltage – 1
    - Low voltage – 0
  - Address line is activated allowing the charge to be transferred to the capacitor
- Read
  - Address line is activated
  - Charge on capacitor is fed out onto a bit line and to a sense amplifier.
  - Sense amplifier compares with reference value and determines if the cell contains 0 or 1.
  - The value is restored
- Used for large memory requirements

Static RAM

- Holds the data as long as the power is supplied
- Read operation don’t destroy the original data.
- Expensive than DRAM but shorter cycle times.
- Used for faster small memories like cache memory.
- Uses 4 – 6 transistors to store a single bit of data
- Less power consumption than DRAM
- Complex construction
- Digital
  - Use flip-flops

SRAM

- Transistor arrangement gives stable logic state
- Logic State 1
  - C_1 high, C_2 low
  - T_1 T_4 off, T_2 T_3 on
- Logic State 0
  - C_2 high, C_1 low
  - T_2 T_3 off, T_1 T_4 on
- Address line controls two transistors T_5 T_6.
- When signal is applied to address line, T_5 and T_6 are on.
- Write – apply value to B & complement to B
- Read – bit value is read from line B



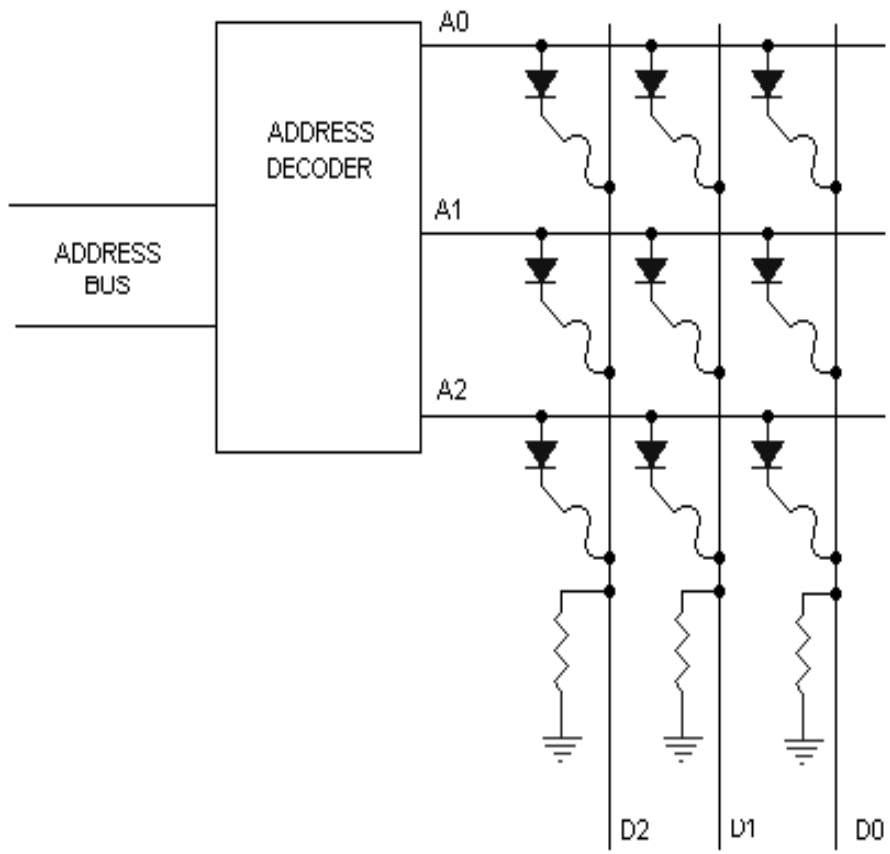
SRAM	DRAM
- Volatile	- volatile
- Faster	- slower
- smaller memory units	- larger memory units
- Complex construction	- simpler to build
- Don’t require refreshing circuit	- require refresh
- Cache memory	- Main memory
- Larger per bit	- smaller per bit
- Digital	- analog

ROM

- Can only be read
- Non-volatile
- Secured – virus do not infect the true ROM
- Applications
  - Microprogramming
  - Library subroutines
  - System programs
  - Function tables

ROM

- Constructed from hard – wired logic encoded in the silicon it self
- If the diode is connected, it binary 1 else 0.

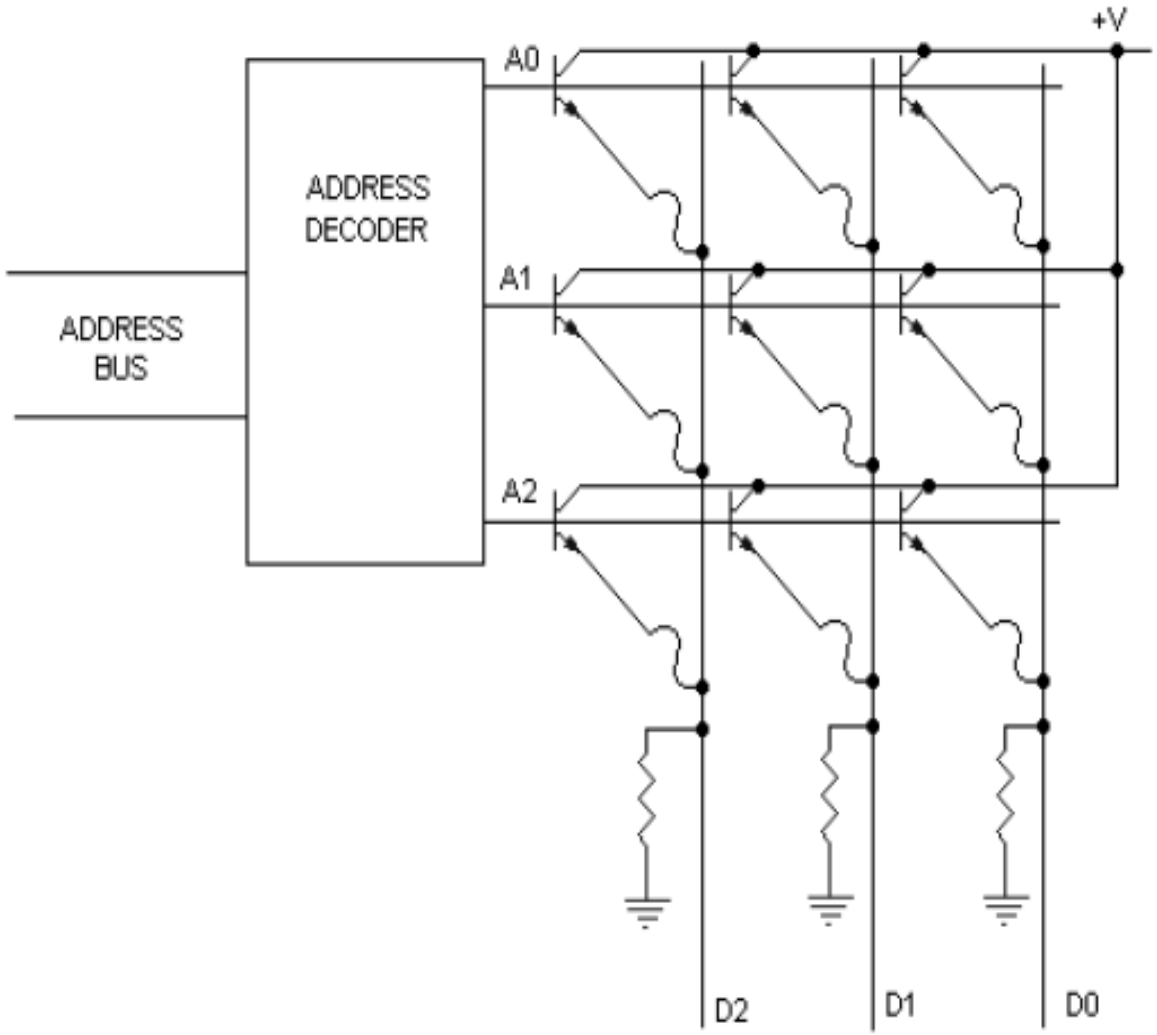


READ ONLY MEMORY (ROM)

Types of ROM

- Written during manufacture
  - Very expensive for small runs
- Programmable (once)
  - PROM
  - Needs special equipment to program
- Read “mostly”
  - Erasable Programmable (EPROM)
    - Erased by UV
  - Electrically Erasable (EEPROM)
    - Takes much longer to write than read
  - Flash memory
    - Erase whole memory electrically

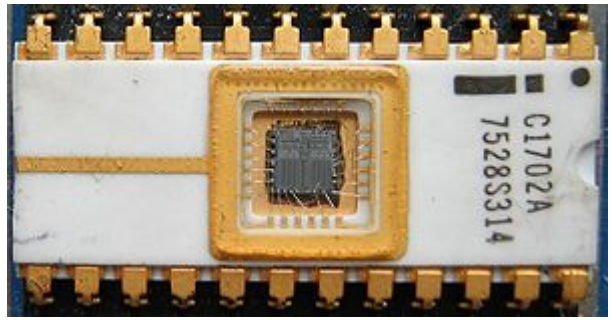
PROM



PROM

- Programmed using a special equipment
- Programming a PROM is also called as burning
- PROM chips have a grid of columns and rows just as ordinary ROMs do.
- The difference is that every intersection of a column and row in a PROM chip has a fuse connecting them.
- Since all the cells have a fuse, the initial state of a PROM chip is all 1s.
- To change the value of a cell to 0, you use a programmer to send a specific amount of current to the cell.
- The higher voltage breaks the connection between the column and row by burning out the fuse.
- This process is known as burning the PROM.

EPROM



•The first EPROM, an Intel 1702, with the die and wire bonds clearly visible through the erase window.

- Erasable programmable
- Erased using UV rays
- A little glass window is installed in the top of the ROM package, through which you can actually see the chip that holds the memory.
- Ultraviolet light of a specific frequency can be shined through this window for a specified period of time, which will erase the EPROM and allow it to be reprogrammed again.
- Changes cannot be made incrementally; the complete chip must be erased
- Fowler-Nordheim tunneling is used to change the value

EEPROM

- Electrically erasable programmable ROM
- Commonly used for BIOS programs.
- The chip does not have to removed to be rewritten.
- The entire chip does not have to be completely erased to change a specific portion of it.
- Changing the contents does not require additional dedicated equipment.
  - Instead of using UV light, you can return the electrons in the cells of an EEPROM to normal with the localized application of an electric field to each cell.
  - This erases the targeted cells of the EEPROM, which can then be rewritten.
- Fowler-Nordheim tunneling is used to change the value

Comparison of different types of main memories

Memory Type	Category	Erasure	Write Mechanism	Volatility
Random-access memory (RAM)	Read-write memory	Electrically, byte-level	Electrically	Volatile
Read-only memory (ROM)	Read-only memory	Not possible	Masks	Nonvolatile
Programmable ROM (PROM)			Electrically	
Erasable PROM (EPROM)	Read-mostly memory	UV light, chip-level		
Electrically Erasable PROM (EEPROM)		Electrically, byte-level		
Flash memory		Electrically, block-level		

References

- William Stallings “Computer Organization and architecture” Prentice Hall, 7th edition, 2006