Sequential Circuits

- This section discusses two sequential circuit components that form the basis for a computer:
  - Registers (temporary storage)
  - Memory (storage of data & instructions)

These memory components are the basic information storage elements of a computer!!
Combinational & Sequential
Microcontroller Example

Sequential Circuits
Register Functions

Register:
A physical location in a processor that can contain a binary number. This location is used to store information temporarily.
The register size is expressed in bits.

Functions:
• Write data to the register/Parallel Load,
• Hold data (no change),
• Shift contents (logical, arithmetic, rotate),
• Clear contents.
Note: One can clearly see the basic ingredients of a sequential circuit: the combinational logic and the memory element.
Registers

Tri-State Buffer

\[ A = 1 \quad \text{I} \quad A = 0 \]

\[ A \quad = \quad \text{I} \quad \text{I} \quad \text{I} \quad \text{O} \quad \text{O} = \text{I} \quad \text{O} \quad \text{O} \]

High-Impedance

Bus line

Registers

Parallel Load: 4-Bit Register, 2-Busses

Often referred to as a Register with:

1 write port
1 read port
 Registers
 Parallel Load: 1-Bit Register, 1-Bus

 Or
 Parallel Load: 1-Bit Register, 1-Bus
Registers

Parallel Load: 1-Bit Register, 1-Bus

Read/write port

R1

Parts of the microcomputer where information is stored

Memory

Primary

Main memory

Cache

Secondary

Hard drive (UDMA/SCSI/etc.)

Floppy/ZIP/LS120 etc. disks

CD-ROM / DVD / Tape Drive etc.

RAM / SRAM / DRAM

ROM / PROM / EPROM / EEPROM
**Semiconductor Memory Devices**

**Types**

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**Random Access Memory**

*(read/write volatile memory)*

- **Dynamic RAM**
  - Stores each bit as a charge on a capacitor
  - Smaller and cheaper, but requires periodic refreshing of capacitors

- **Static RAM**
  - Stores each bit in a flip-flop (like the registers)
  - Larger and faster, does not require periodic refreshing
RAM

Memory Cell: That’s where a bit of information is stored

(m+n) total address bits

Row Address

Row Decoder

2^{m-1} 2^m

2^m

n

Column Address

Column Multiplexer

A_2 A_1 A_0

3-to-8 Decoder

A_5 A_4 A_3

3-to-8 multiplexer

Note: 2^6 = 64

Example: 64x1

RAM
Static RAM
Memory Cell

As long as the chip is powered, memory remains!

Dynamic RAM
Memory Cell

The capacitor requires a regular refreshing cycle b/c it will slowly discharge!