Digital Circuits and Computer Design

Notes #6

"Sequential Circuits: *Registers & RAM*"

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Acknowledgement: Dr. Maarten Uijt de Haag

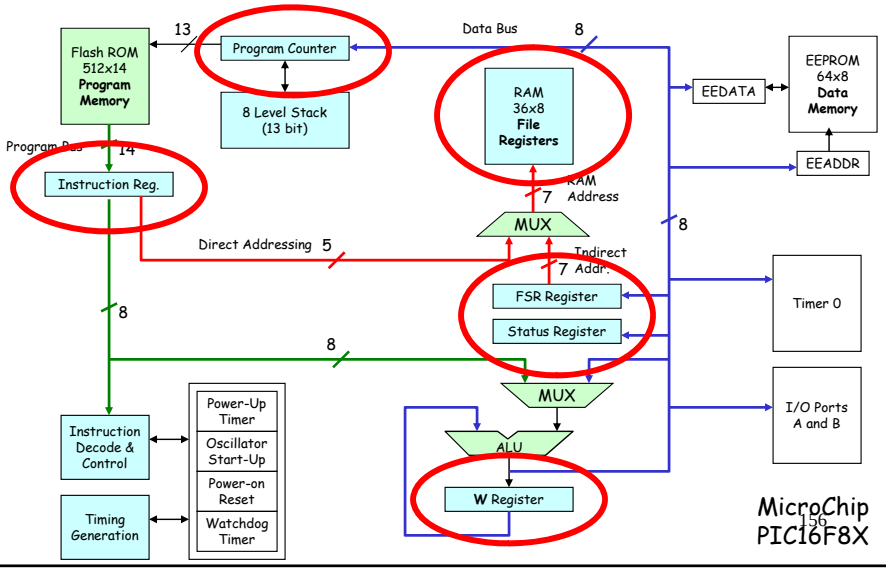
Sequential Circuits

- 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

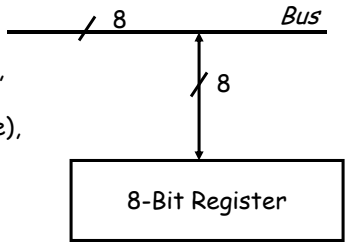


Sequential Circuits

Register Functions

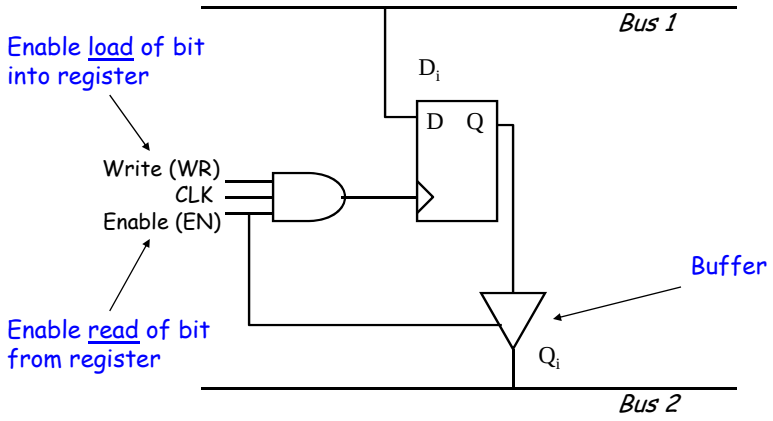
Register:
A physical location in a processor that can contain a binary number.
This location is used to store information temporarily.
The register size is expressed in bits.

Functions:
- Write data to the register/ Parallel Load,
- Hold data (no change),
- Shift contents (logical, arithmetic, rotate),
- Clear contents.



Registers

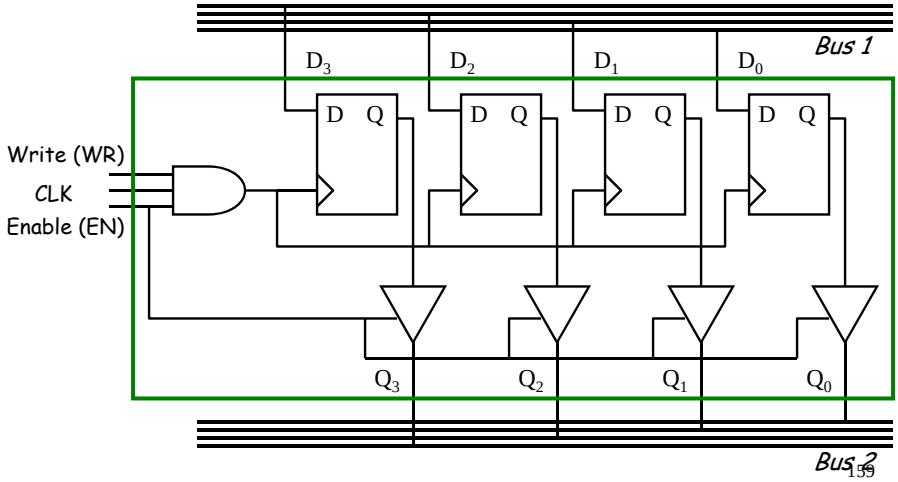
Parallel Load : 1-Bit Register 2-Busses



Note: One can clearly see the basic ingredients of a sequential circuit; the combinational logic and the memory element

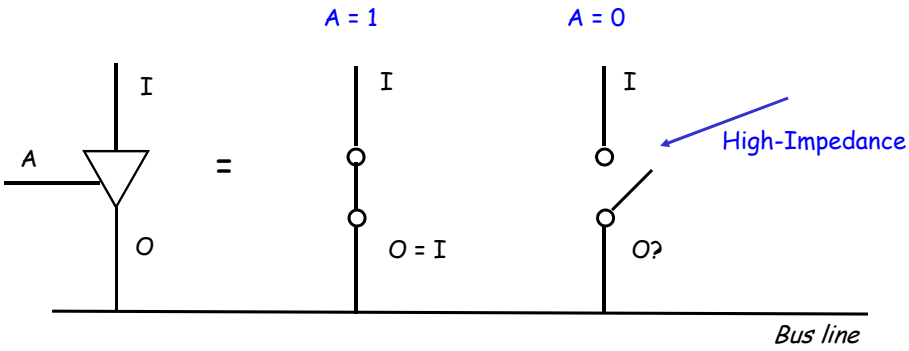
Registers

Parallel Load : 4-Bit Register



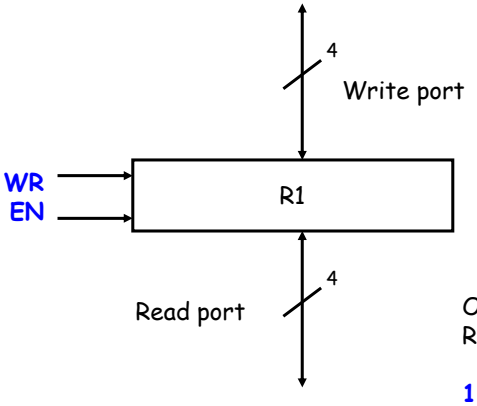
Registers

Tri-State Buffer



Registers

Parallel Load : 4-Bit Register, 2-Busses

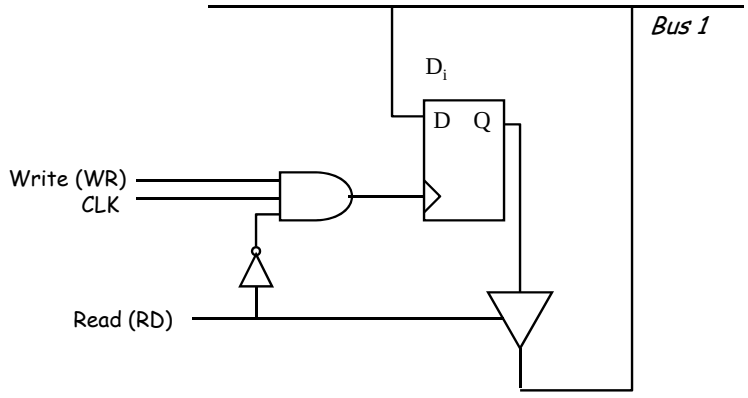


Often referred to as a Register with:

1 write port
1 read port

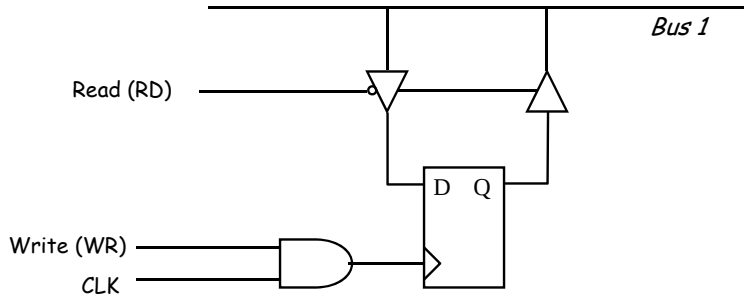
Registers

Parallel Load : 1-Bit Register, 1-Bus



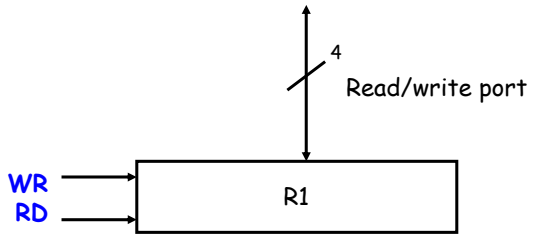
Or

Parallel Load : 1-Bit Register, 1-Bus



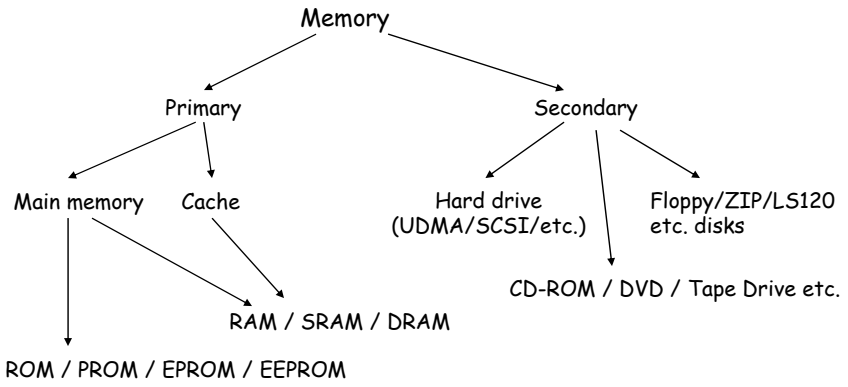
Registers

Parallel Load : 1-Bit Register, 1-Bus



Hardware: Memory

Parts of the microcomputer where information is stored



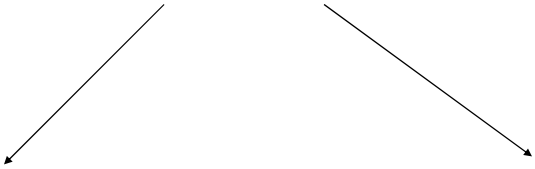
Semiconductor Memory Devices

Types

Memory Type	Category	Erasure	Write mechanism	Refresh mechanism	Volatility
Random-Access Memory (RAM):	Read-write Memory	Electrically, Byte level	Electrically	Depends	Volatile
Static RAM (SRAM)				Not necessary	
Dynamic RAM (DRAM)				Necessary	
Read-only Memory (ROM)	Read-only Memory	Not Possible	Masks	Not applicable	Non-volatile
Programmable ROM (PROM)			Electrically		
Erasable PROM (EPROM)	Read-mostly Memory	UV Light, Chip level			
Flash memory		Electrically, Block level			
Electrically EPROM (EEPROM)		Electrically, Byte level			

Random Access Memory

(read/write volatile memory)



Dynamic RAM

Stores each bit as a charge on a capacitor

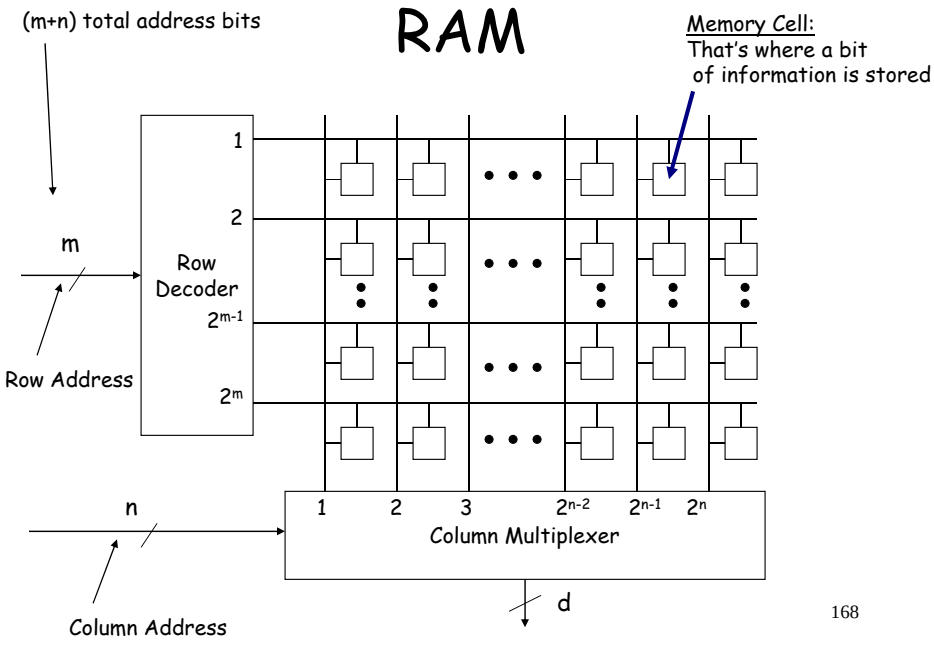
- Smaller and cheaper, but requires periodic refreshing of capacitors

Static RAM

Stores each bit in a flip-flop (like the registers)

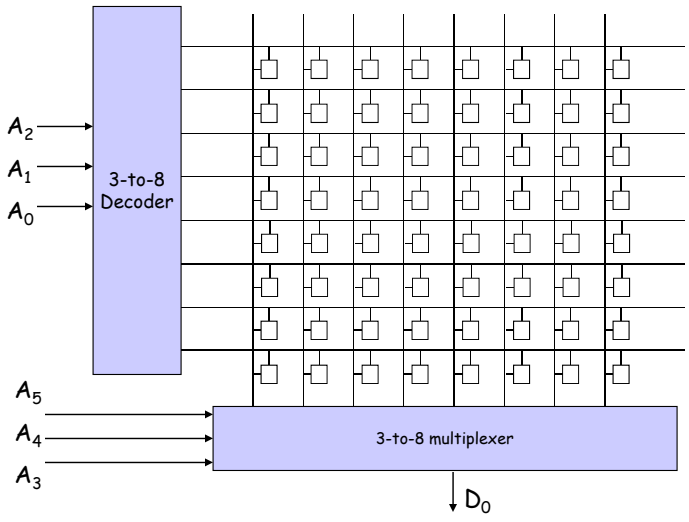
- Larger and faster, does not require periodic refreshing

RAM



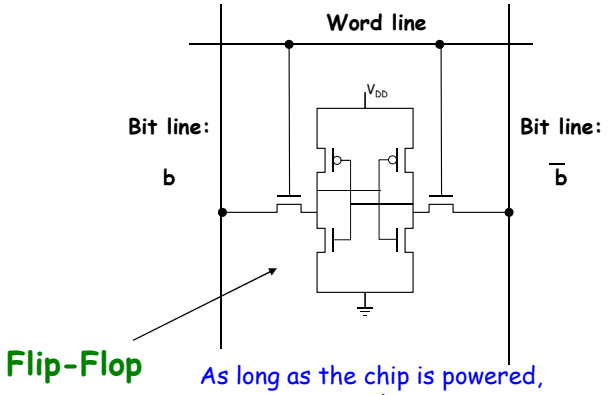
RAM

Example: 64x1



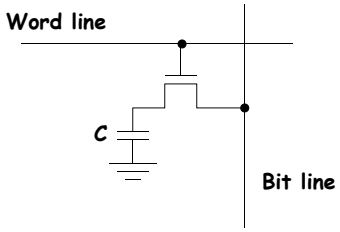
Note:
$2^6 = 64$

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 !