UNIVERSITI TENAGA NASIONAL

CHAPTER 6
INTERNAL MEMORY

CGMB143 COMPUTER SYSTEM

Objectives

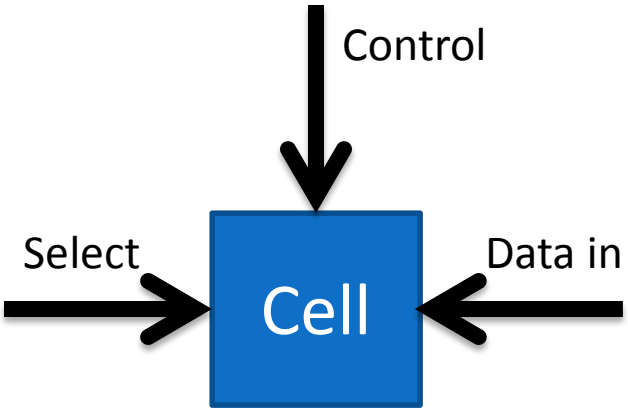
- To study the types of semiconductor main memory subsystems
  - RAM
  - DRAM
  - SRAM
- ROM
- Error correction

Semiconductor Main Memory

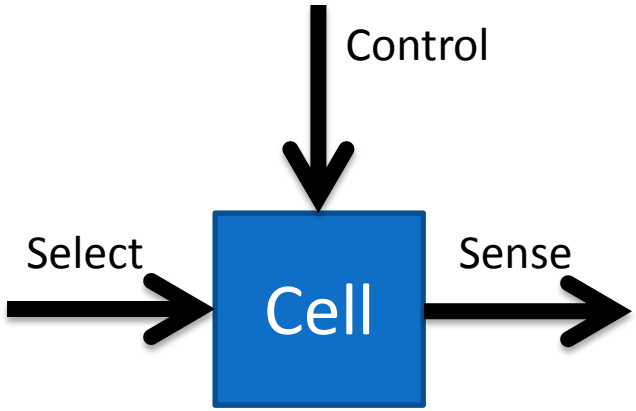
- Basic element of semiconductor main memory (smm) – memory cell
- Cell properties;
  - 2 stable states – 0 and 1 ← binary
  - Capable of being written to set the state
  - Capable of being read to sense the state

Memory Cell Operation

Write



Read



Functional Terminal - Capable of carrying an electrical signal

Three Functional Terminals

- Select terminal – select memory cell for read or write operation
- Control terminal – indicates read or write
  - Write – other terminal provides an electrical signal → sets the state of the cell to 1 or 0
  - Read – that terminal is used for output of the cell's state

All memory types in this chapter are random access

Semiconductor Memory Types

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		

SEMICONDUCTOR MEMORY

All semiconductor memory is random access

DRAM

SRAM

Random Access Memory (RAM)

- Characteristic
  - Read/Write – read data from the memory and to write new data into the memory
    - Use electrical signals
  - Volatile – must have constant power supply else data lost.
  - Temporary storage
- 2 traditional forms of RAM
  - DRAM
  - SRAM

Dynamic RAM (DRAM)

- Made with cells that store data as charge on capacitors
- The presence or absence of charge in a capacitor is interpreted as a binary 1 or 0
  - Capacitors have tendency of discharging - needs to periodically charge to maintain data storage
- The term dynamic refers to this tendency of the stored charge to leak away

DRAM Operation

Write

- A voltage signal is applied to the bit line
- A high voltage represent 1, a low voltage represent 0
- A signal is then applied to the address line allowing a charge to be transferred to the capacitor

Read

- Select address line. The transistor turns on and the charge stored on the capacitor is fed out onto a bit line and to a sense amplifier
- The sense amplifier compares the capacitor voltage to a reference value and determines if the cell contains a logic 1 or logic 0
- The readout from the cell discharges the capacitor which must be restored to complete the operation

DRAM (Cont.)

- Analog device
- Capacitor stores any charge value within a range
  - Threshold value – determine whether the charge is interpreted as 0 or1

Static RAM (SRAM)

A digital device

Use the same logic elements as in the processor

The binary values are stored using traditional flip-flop logic gate configuration

Data remains as long as power is supplied to it

DRAM versus SRAM

Volatile – need power to preserve data

DRAM

- Simpler to build, smaller
- More dense
- Less expensive
- Needs refresh
- Larger memory units
- Use as main memory

SRAM

- Faster
- Use as cache memory

Read Only Memory (ROM)

- Permanent storage
  - Nonvolatile
- Use in
  - Microprogramming
  - Library subroutines
  - Systems programs (BIOS)
  - Function tables

Types of ROM

- ROM
- PROM
- EPROM
- EEPROM
- Flash memory

ROM

- Data is written during manufacture

PROM – Programmable ROM

- Nonvolatile
- Written once
  - Electrically – supplier or user
  - Perform after fabrication
  - Need special equipment to program

EPROM – Erasable PROM

- Read/write electrically
- Before a write operation, empty the cells by ultraviolet radiation
- The erase procedure can be performed repeatedly
- Expensive than PROM

Flash Memory

- Intermediate between EPROM and EEPROM; cost and functionality
- Use an electrical erasing tech; much faster than EEPROM
- Possible to erase just blocks of memory

EEPROM – Electrical EPROM

- Can be written into at any time without erasing prior contents - updates bytes address
- Write operation is longer than read operation
- Nonvolatile and flexible in update using ordinary bus control

Chip Logic

- Each chip contains an array of memory cells
- The array is organized into W words of B bits each.
- Example : a 16 –Mbit chip could be organized as 1 M 16 words. (word- is a fixed sized group of bits that are handled as a unit by the instruction set and/or hardware of the processor)

Interleaved Memory

- Advance technique used by high-end motherboards/chipsets to improve memory performance
- Increase bandwidth by allowing simultaneous access to more than one bank of memory
- Improves performance since CPU/processor can transfer more information to/from memory in the same amount of time, and helps ease the CPU-memory bottleneck

ERROR CORRECTION

Errors

- A semiconductor memory is subject to errors.
- Categories;
  - Hard failures
  - Soft errors
- Example : power supply problem

Errors – Categories

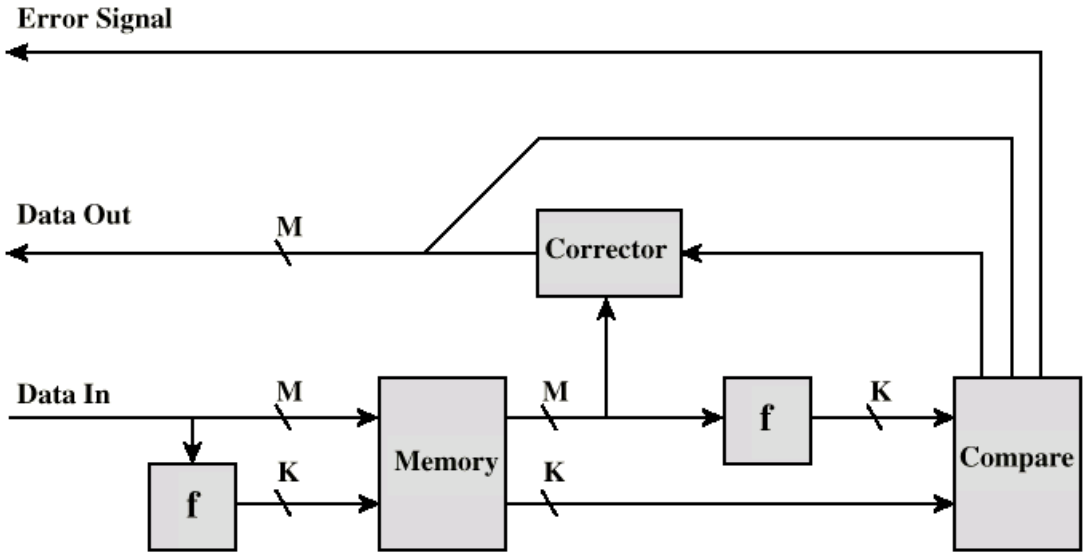
Hard Failures

- A permanent physical defect so that the memory cells affected cannot reliably store data but become stuck at 0 or 1

Soft Error

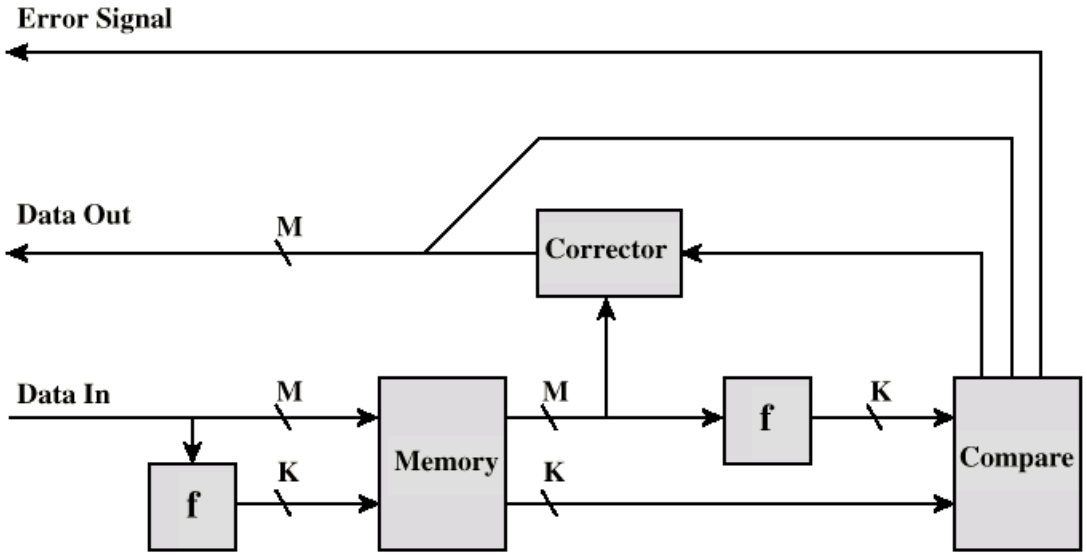
- A random, nondestructive event that alters the contents of one or more memory cells without damaging the memory

Process of Detecting and Correcting Errors



- When data are to be read into memory, a calculation, function f is performed on the data to produce a code
- Both the code and the data are stored
- If M –bit word of data is to be stored and the code is of length K bits, then the actual size of the stored word is M + K bits

Process of Detecting and Correcting Errors (Cont.)



- When the previous stored word is read out, the code is used to detect and possibly correct errors
- A new set of K code bits is generated from the M data bits and compared with the fetched code bits

Process of Detecting and Correcting Errors (Cont.)

- Three results of the comparisons;
  - No errors-the fetched data bits are sent out
  - An error is detected-possible to correct, the data bits +error correction bits are fed out into a corrector, which produces a corrected set of M bits to be sent out
  - An error is detected and connect be corrected, this condition is reported

Process of Detecting and Correcting Errors (Cont.)

- The codes are referred as error-correcting codes
- A code is characterized by the number of bit errors in a word that it can correct and detect
- The simplest error-correcting codes is the Hamming code