Digital Electronics

Principles & Applications

Seventh Edition

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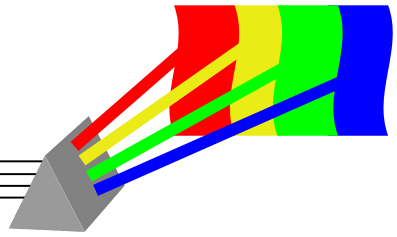
Chapter 11

Memories



INTRODUCTION

- Overview of Memory
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Programmable ROM (PROM)
- Nonvolatile Read/Write Memory
- Memory Packaging
- Computer Bulk Storage Devices
- Digital Potentiometer with NV EEPROM

Overview of Memory

Three Important Characteristics of Semiconductor Memory:

- *Density*
  - Amount of data that the memory can store

- *(Non-) Volatility*
  - Data storage capability if power is disconnected

- *Read/write capability*
  - Capability to update memory

QUIZ

1. Three important characteristics of semiconductor memory are (1) density, (2) non-volatility, and (3) a read/write capability. (True or False)

   True

2. High density (small memory cell size) is a desirable characteristic of modern semiconductor memories. (True or False)

   True

3. Generally, if a semiconductor memory is nonvolatile this is a desirable characteristic. (True or False)

   True

4. A semiconductor memory that can be updated is referred to as a(n) _____ (read-only, read/write) memory.

   read/write

Overview of Memory (Continued)

Categories of Semiconductor Storage Cells:

- DRAM (Dynamic Random-Access Memory)
- SRAM (Static Random-Access Memory)
- ROM (Read-Only Memory)
- EPROM (Electrically Programmable ROM)
- EEPROM (Electrically Erasable PROM)
- Flash Memory
- FRAM (Ferroelectric RAM)
- MRAM (Magnetoresistive RAM)

See future slides for characteristics of each category of memory.

QUIZ

1. SRAM is an acronym for _____.

Static Random-Access Memory

2. ROM is an acronym for _____.

Read-Only Memory

3. DRAM is an acronym for _____.

Dynamic Random-Access Memory

4. EEPROM is an acronym for _____.

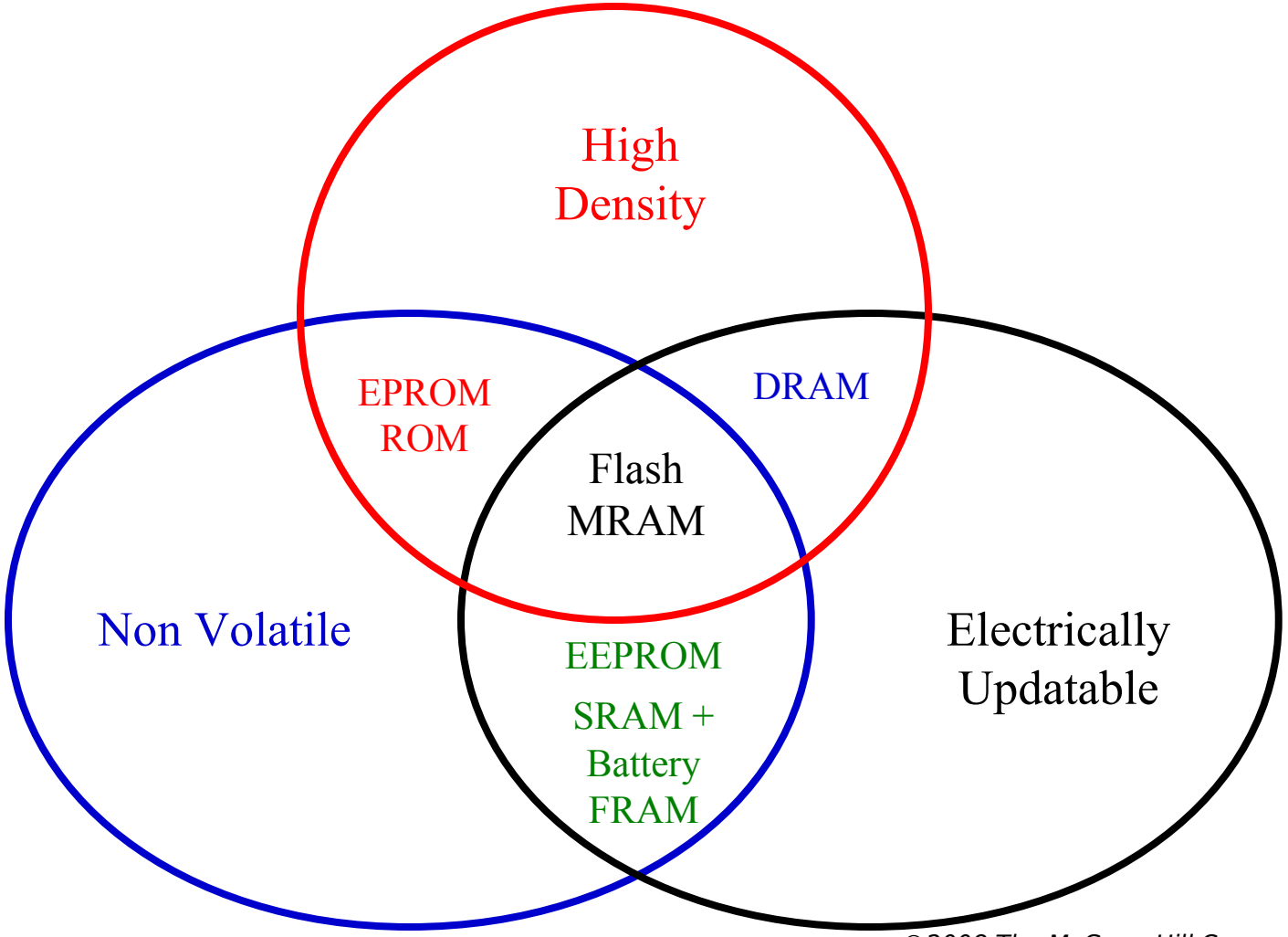
Electrically Erasable PROM

5. PROM is an acronym for _____.

Programmable ROM

Overview of Memory (Continued)

Important Semiconductor Memory Characteristics:



QUIZ

1. Both a ROM and EPROM are nonvolatile and have high density but cannot be electrically updated. (True or False) — True
2. The DRAM is a high density semiconductor memory that _____ (can, cannot) be electrically updated. — can
3. The _____ (Flash, PROM) is a modern memory that exhibits high density, is nonvolatile, and can be updated electrically. — Flash
4. SRAM with a battery backup (as in modern PCs) is nonvolatile, and can be updated electrically. (True or False) — True
5. FRAM and MRAM are both non-volatile RAMs using newer technologies. (True or False) — True

Random-Access Memory (RAM)

Characteristics of RAM:

- Data can be "written" to RAM
- Stored data can be "read" at any time
- *Volatile* - cannot be used for permanent memory
- Access to any memory location (address) at any moment

Types of RAM:

- SRAM (Static RAM) - stores data in flip-flop-like cells. Holds 0 or 1 as long as IC has power (volatile).
- DRAM (Dynamic RAM) - memory cells need refreshing many times per second. Also volatile.

QUIZ

1. Two types of RAM semiconductor memories are the DRAM and _____. SRAM
2. The RAM is a _____ (non-volatile, volatile) semiconductor memory. volatile
3. Modern computers contain both SRAM and DRAM types of semiconductor memories. (True or False) True
4. Both SRAM and DRAM are types of read-only semiconductor memories. (True or False) False
5. RAM semiconductor memory has exactly the same characteristics as Flash memory because they are non-volatile, can be updated electrically, and have high density. (True or False) False

Read-Only Memory (ROM)

Characteristics of ROM:

- *Non-volatile* - memory is not lost when power is turned off
- Data is stored permanently
- Data stored in ROM can be “read” at any time
- ROM cannot be reprogrammed
- High density

QUIZ

1. ROM stands for _____. Read-Only Memory
2. ROM is a semiconductor memory that can be updated electrically and is volatile. (True or False)

   False
3. ROM is a high density semiconductor memory that _____ (can, cannot) be reprogrammed. cannot
4. Data is stored permanently in a ROM semiconductor memory. (True or False) True

Programmable Read-Only Memory (PROM)

Data can be programmed or "burned" into a PROM.

Types of PROM:

- Mask-Programmable ROM (usually simply called ROM)
- Field-Programmable ROM (PROM)
- Erasable Programmable ROM (EPROM)
- Electrically Erasable PROM (EEPROM or E^2PROM)
- Flash EEPROM

QUIZ

1. PROM stands for _____.

   Programmable Read-Only Memory

2. A mask-programmable ROM can only be programmed once and is generally known as a ROM. (True or False)

   True

3. An EEPROM is an electrically erasable PROM that is non-volatile and can be updated electrically. (True or False)

   True

4. A Flash memory is an electrically erasable PROM that has high density, is volatile, and cannot be updated electrically. (True or False)

   False

QUIZ

1. Memory that retains its stored information even when power is turned off is referred to as _____ (volatile, nonvolatile). nonvolatile

2. SRAM is a _____ (volatile, nonvolatile) type of semiconductor memory. volatile

3. SRAM with battery backup as used in modern PCs is a _____ (volatile, nonvolatile) type of semiconductor memory. nonvolatile

4. Flash memory features high density, is reliable, can be electrically updated and is _____ (volatile, nonvolatile). nonvolatile

Other Nonvolatile RAM

(Using newer technologies)

- FRAM (ferroelectric RAM)
  - -Nonvolatile RAM
  - -In-circuit programmable
  - -Good access speed
  - -Low density
  - -High cost
  - -Ferroelectric capacitor and MOS transistor memory cell

- MRAM (magnetoresistive RAM)
  - -Nonvolatile RAM
  - -In-circuit programmable
  - -Excellent access speed
  - -High density
  - -Nanotechnology used in fabrication

Common Methods of Packaging Semiconductor Memory

- DIP (Dual In-line Package)
- SIP (Single In-line Package)
- ZIP (Zig-zag In-line Package)
- SIMM (Single In-line Memory Module)
- DIMM (Dual-In-line Memory Module)
- RIMM (like DIMM by Rambus, Inc.)
- Memory card (like Flash memory card)

Computer Bulk Storage Devices

Primary storage - computer's internal storage
Secondary storage - external storage

Types of secondary storage devices:

- Mechanical Devices
  - Punched paper card
  - Punched or perforated paper tape
- Magnetic Devices
  - Magnetic tape (sequential-access device)
  - Magnetic drum
  - Hard disk
  - Floppy disk

Computer Storage Devices

Types of Secondary Storage Devices (cont'd.):

- Optical Devices
  - CD-ROM (Read-only)
  - CD-R (recordable)
  - CD-RW (rewritable)
  - WORM (Write-once Read-many
  - DVD (Digital versatile disc or digital video disc)
  - Magneto-optical disc- part optical/part magnetic
- Semiconductor Devices
  - Flash EEPROM semiconductor memory

QUIZ

1. A 3.5 inch floppy disk is an example of a _____ (primary, secondary) storage device. secondary

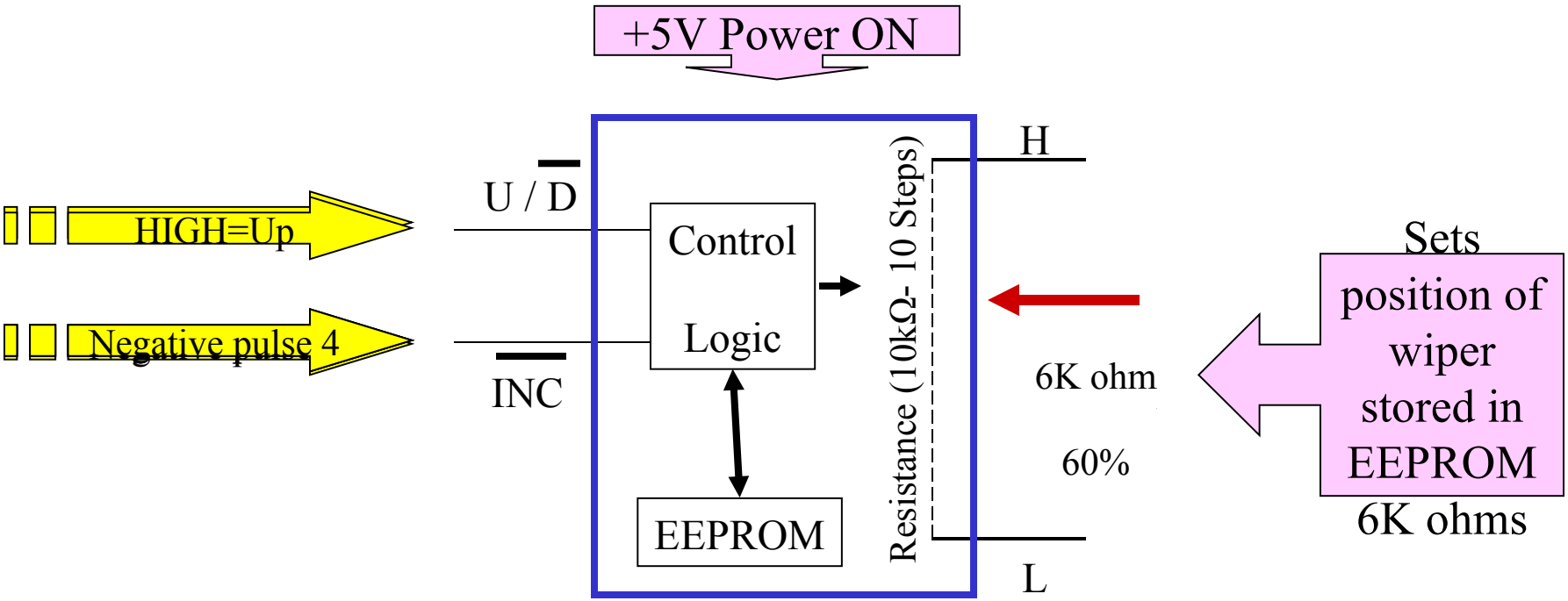
2. The SRAM in your PC is an example of a _____ (primary, secondary) storage device. primary

3. The CD-R optical disc is _____ (recordable, rewritable). recordable

4. The CD-RW optical disc is _____ (recordable, rewritable). rewritable

Digital Potentiometer

Digital potentiometer is an electronic device comparable to a traditional potentiometer with resistance outputs variable in discrete steps. The wiper position is stored in EEPROM when the power is turned off. Digital input pulses control the movement of the wiper. Also referred to as a solid-state potentiometer or non-volatile (NV) digital potentiometer.



QUIZ

1. The electronic equivalent of a potentiometer is called a solid-state potentiometer or _____.

   Digital potentiometer

2. The digital potentiometer contains a _____ (EEPROM, ROM) section to store the wiper position on power down and recall the wiper position on power up.

   EEPROM

3. A single negative pulse will cause the wiper of a digital potentiometer to move one discrete step up or down depending on the condition of the U/D' control input. (True or False)

   True

REVIEW

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