

Memory and Data Storage Devices



Memory Devices

Memory devices are electronic devices that store information for immediate use in electronic hardware. Memory devices utilize **digital logic** to perform their operations.

Examples:

- EEPROM
- RAM
- Flash Memory



LaACES Student Ballooning Course Building Blocks of Memory

Memory devices are often constructed on a hardware level with logic gates and simple memory circuits such as latches and flip-flops.

Types of Logic Gates:

• AND, OR, NOT, NAND, NOR

Types of Latches

• SR NOR, SR NAND, SR AND-OR

Types of Flip-Flops

• D Flip-Flop, T Flip-Flop, JK Flip-Flop



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Memory Types

There are two main types of memory devices: volatile and non-volatile

Volatile Memory is memory that requires power to maintain stored information (Ex. RAM)

By contrast, **Non-Volatile Memory** is computer memory that stores information even after power has been cycled. (Ex. Flash memory)



ROM

- **Read-Only Memory (ROM)** is a type of non-volatile memory used to store programs and data
- Traditional ROM cannot be changed after it has been written
- EEPROM and EPROM are types of ROM that can be changed after the initial programming. The write time for such devices is often relatively slow
- EEPROMs have a finite amount of times it be erased and rewritten
- Often used to store software or data that is rarely changed (ex. firmware, lookup tables)



Flash Memory

- Flash memory is a type of non-volatile computer memory that can be erased and reprogrammed
- Flash memory is based on EEPROM with larger memory block sizes
 - Technically Flash is a type of EEPROM
 - Usually "EEPROM" use NOR and "Flash" use NAND
 - "EEPROM" small, "Flash" large
- Flash memory is often used for large solid-state digital storage
- Solid-state hard drives are often made using flash memory



RAM

- Random Access Memory (RAM) is a type of volatile computer memory where memory cells can be accessed in any order
- Since programs do not need to look up addresses for memory, RAM is significantly faster than other memory devices
- RAM is often used for programs or software that are actively being used



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Ballooning Course Magnetic Hard Disk Drive

- Hard disk drives are non-volatile memory devices used for storing large amount of data
- Data is stored in individual blocks of memory that can be stored or retrieved in any order
- Data is saved by magnetizing ferromagnetic material on a disk using a magnetic lever. The encoding allows for data to be stored even when power is lost
- Primarily used as secondary storage devices for computers.



SD Cards

- Secure Digital (SD) cards are a type of non-volatile memory devices used for portable devices
- SD cards utilize flash memory to store large quantities of data in a small physical size
- SD Cards are available in multiple storages size ranging from 512 MB to 1 TB
- SD, SDHC, SDXC, SDUC are simply standards of increasing size and write speed and generally not important for Arduino usage





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Student Ballooning Course SD Cards Physical Details

- SD cards are available in three physical sizes: standard, miniSD, and microSD
- Standard: 32 mm x 24 mm x2.1 mm
- Mini: 32 x 20 mm x 1.4 mm
- Micro: 15 mm x 11mm x1.0 mm
- The pinout for each size varies





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SD Cards File Systems

- An SD card (or any storage device) uses a particular format to store/arrange its flies.
- The file system places maximum limits on the total storage size and on single file size
- For SD cards you are likely to encounter one of the versions of the File Allocation Table (FAT)
 - Under 2GB have FAT16
 - 2- 32 GB FAT32
 - >32 GB exFAT
- One detail to keep in mind is that a libraries that are compatible with larger file systems will require larger amounts of the Arduinos RAM

File System	Max Volume Size	Maximum Single File Size
FAT16	2 GB	2 GB
FAT32	32 GB	4 GB
ExFAT	128 PetaB	2 ExaB



Using the SD Formatting Utility

- It is useful to be able to completely erase the SD using the formatting utility <u>Utility</u> from the SD card Association
- Download the correct version for you operating system
- Formatting the card will erase all the data on the card
- When the SD card is inserted into the computer the Card should appear under the select card drop down and the Card Information should update

SD Card Formatter
File Help
Select card
D:\ ~
Refresh
Card information
Type SDHC SDHC
Capacity 29.81 GB
Formatting options Quick format
Overwrite format
CHS format size adjustment
Volume label
Format
SD Logo, SDHC Logo and SDXC Logo are trademarks of SD-3C, LLC.



Formatting FAT32

- The utility will automatically select the appropriate file system for the size card.
- You can see here that the 32GB SD card was formatted in FAT32





Formatting ExFAT

- And here a 1 TB SD card was formatted to exFAT
- It is important to know which file system was selected because not all file systems are supported by all libraries
- Also, note there are 2 format options
 - Quick just marks the space as available to overwrite
 - Overwrite Actually erases the data by overwriting it



SD Card Formatter	
File Help	
Select card	
D:\	~
SD Card F	formatter X
Ca Tyr Ca Fo O	Formatting was successfully completed. Volume information: File system: exFAT Capacity: 953.43 GB (1,023,737,331,712 bytes) Free space: 953.43 GB (1,023,735,758,848 bytes) Cluster size: 512 kilobytes Volume label:
Vol	ОК
SDLo	Format
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Write Speed Standards

- You may see references to the "Class" or markings like those shown to the right
- These refer to write speed standard the card must achieve

