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

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

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

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.
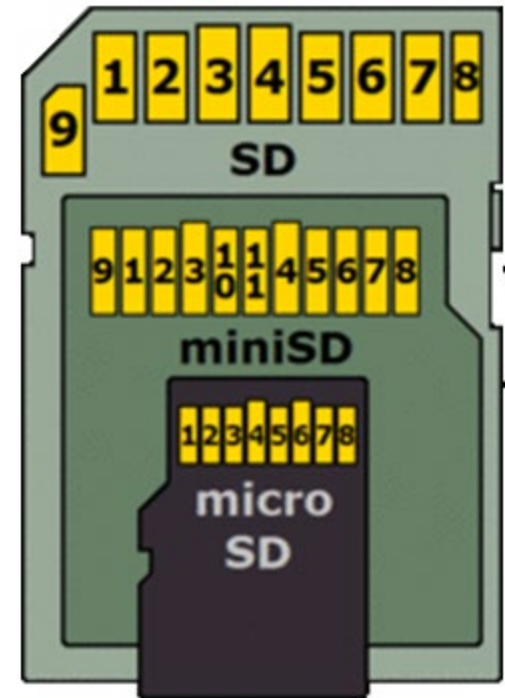
SD Cards

- 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

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
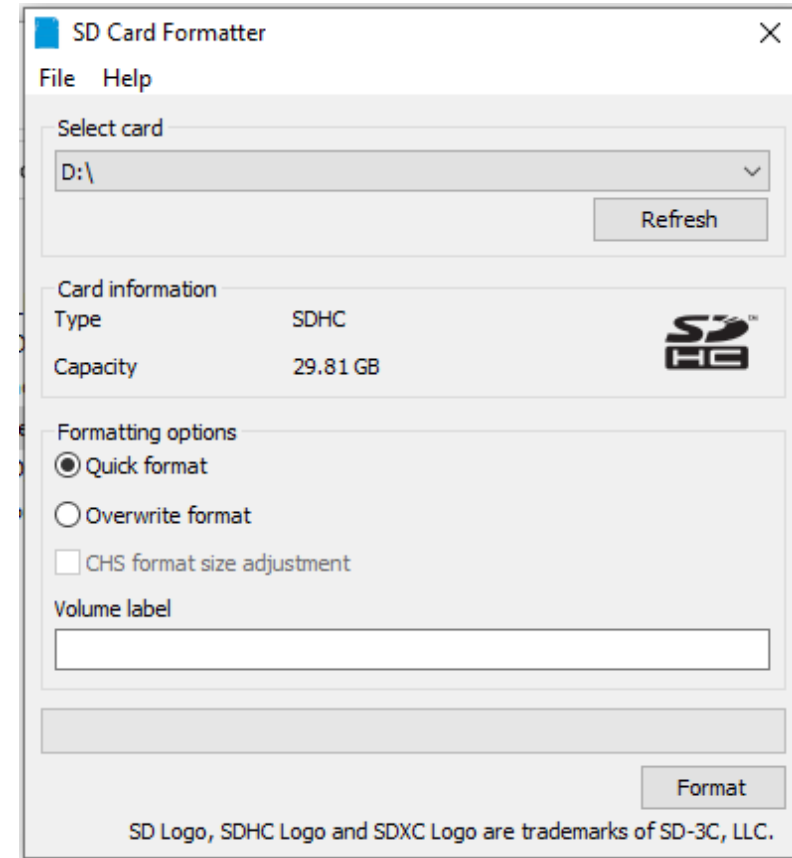
SD Cards File Systems

- 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
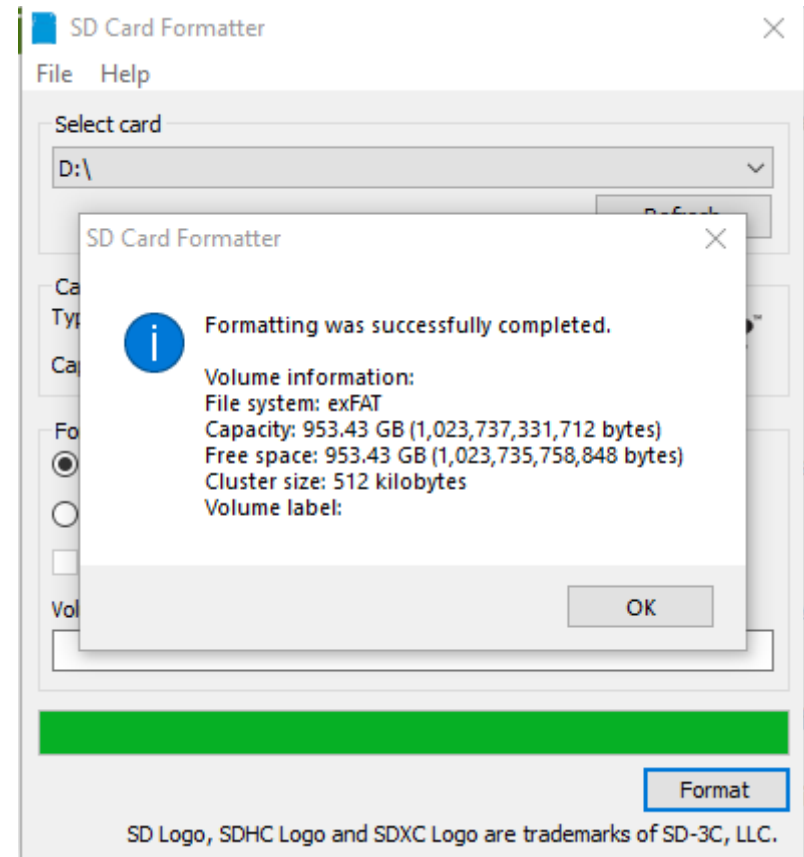
Formatting FAT32

- 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
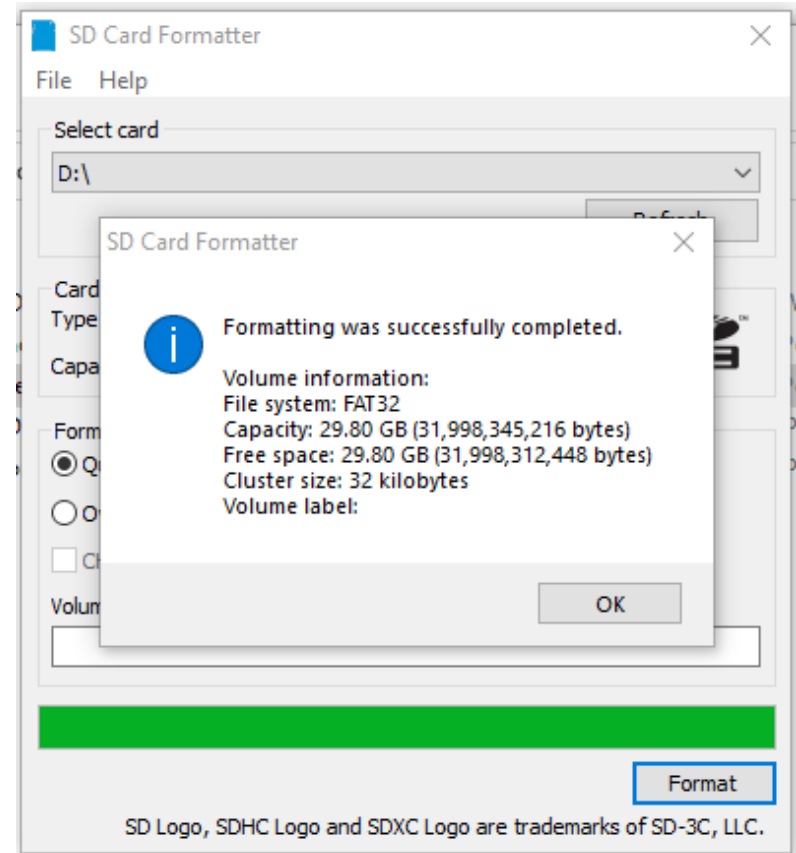
Formatting ExFAT

- 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 Formatter

ⓘ 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:

OK

Format

SD Logo, SDHC Logo and SDXC Logo are trademarks of SD-3C, LLC.

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

- These speeds are far higher than the Arduino will be able to achieve so not a specification we need to be concerned about

"Speed Class" Mark   "UHS Speed Class" Mark   "Video Speed Class" Mark