



# Understanding microSD and SD cards: speeds, markings and more

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<https://learn.adafruit.com/understanding-microsd-and-sd-cards-speeds-markings-and-more>

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# Overview

“SD” or [Secure Digital \(https://adafru.it/UTc\)](https://adafru.it/UTc) was developed by the SD Association and is a proprietary non-volatile memory card format for use in portable devices. An SD card and its smaller counterpart, the microSD card, can be found in a variety of everyday devices including cameras, smartphones, drones, video game consoles like the Nintendo Switch, and more.



While SD and microSD cards have made recording data faster and storage capacity has become greater, there is still much confusion. Each device, from a camera to a drone, has different SD card requirements. For example, a drone may require a microSD card with a [high speed class rating \(https://adafru.it/UTd\)](https://adafru.it/UTd) to write data very fast, but if the card you give it has a lower rating that can't write fast enough, it may not be compatible with the drone. Such mistakes are common, but don't fret. This guide will show you how to avoid using and buying the wrong SDs for your devices. By the end, you'll be an SD pro.

## Confused and in a dash?

If you need SD info in a jiffy we got you covered. **When in SD doubt, check this graphic out!** (Click to enlarge)

**COMPARISON OF SD CARD SPEED CLASS RATINGS AND SUGGESTED USE CASES**

MINIMUM SEQUENTIAL WRITING SPEEDS	SPEED CLASSES				VIDEO FORMATS				SUGGESTED USE CASES	
	SPEED CLASS	LOGO	UHS SPEED CLASS	LOGO	VIDEO SPEED CLASS	LOGO	SD	H264		HEVC
2MB/s	Class 2		-	-	-	-	Yes	No	No	Audio Recording, Low-res SD Video
4MB/s	Class 4		-	-	-	-	Yes	Yes	No	Consumer Point and Shoot Cameras
6MB/s	Class 6		-	-	Class 6	V6	Yes	Yes	No	Shooting Basic JPEGs, Smart Phones, Tablets
10MB/s	Class 10		Class 1		Class 10	V10	Yes	Yes	No	Raspberry Pi, MCU Breakouts, Burst Shooting, Slow Photography
30MB/s	Class 10		Class 3		Class 30	V30	Yes	Yes	Yes	4K Drone Filming, RAW Images in Burst Mode
60MB/s	Class 10		Class 9		Class 60	V60	Yes	Yes	Yes	Ultra High Resolution Filmmaking
90MB/s	Class 10		Class 3		Class 90	V90	Yes	Yes	Yes	Ultra High Resolution Filmmaking

COMPARISON OF SD CARD CAPACITY STANDARDS				
SD CARD TYPE	LOGO	CAPACITY MINIMUM	CAPACITY MAXIMUM	TYPICAL FS
SD		-	2 GB	FAT12/FAT16
SDHC		>2 GB	32 GB	FAT32
SDXC		>32 GB	2 TB	exFAT
SDUC		>2 TB	128 TB	exFAT

COMPARISON OF SD CARD BUS SPEEDS		
BUS INTERFACE	BUS LOGO	PEAK THROUGHPUT
Default Speed	-	12.5 MB/s
High Speed	-	25 MB/s
UHS-I	<b>I</b>	50 - 104 MB/s
UHS-II	<b>II</b>	156 - 312 MB/s
UHS-III	<b>III</b>	312 - 624 MB/s
SD Express	<b>EX</b>	985 - 1969 MB/s
SD Express	<b>EXPRESS</b>	1969 - 3938 MB/s

COMPARISON OF SD CARD APPLICATION PERFORMANCE CLASS RATINGS			
APPLICATION PERFORMANCE CLASS	MINIMUM IOPS READ	MINIMUM IOPS WRITE	MINIMUM SUSTAINED SEQUENTIAL WRITING
<b>A1</b> Application Performance Class 1	1500 IOPS	500 IOPS	10 MB/s
<b>A2</b> Application Performance Class 2	4000 IOPS	2000 IOPS	10 MB/s



**SD/MicroSD Memory Card (8 GB SDHC)**  
 Add mega-storage in a jiffy using this 8 GB class 4 micro-SD card. It comes with a SD adapter so you can use it with any of our shields or adapters. Preformatted to FAT so it works out...  
<https://www.adafruit.com/product/1294>



**SD/MicroSD Memory Card - 16GB Class 10 - Adapter Included**  
 Add speedy mega-storage in a jiffy using this 16 GB Class 10 micro-SD card. It comes with a SD adapter so you can use it with any of our shields or adapters! Preformatted to FAT so it...  
<https://www.adafruit.com/product/2693>

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# SD vs microSD

## How does an SD card work anyhow?

Both microSD and SD cards work generally the same. [Each card uses a tiny processor and one or two small NAND flash memory chips to manage the flow of data and instructions.](https://adafru.it/UTe) (<https://adafru.it/UTe>) Using these electronic components, the SD card is able to write and read data at dizzying speeds. These speeds can range from 2 [megabytes](https://adafru.it/UTf) (<https://adafru.it/UTf>) per second to up to 90 MB/s.

MiniSD is another SD format, however it's not as widely used anymore, so it is not including in this guide.

CompactFlash, CFast and XQD memory cards are not covered in this guide.



Above: Inside a 2 GB SD card - two [NAND flash](https://adafru.it/UTA) (<https://adafru.it/UTA>) chips (top and middle), SD controller chip (bottom)

### Data transfer

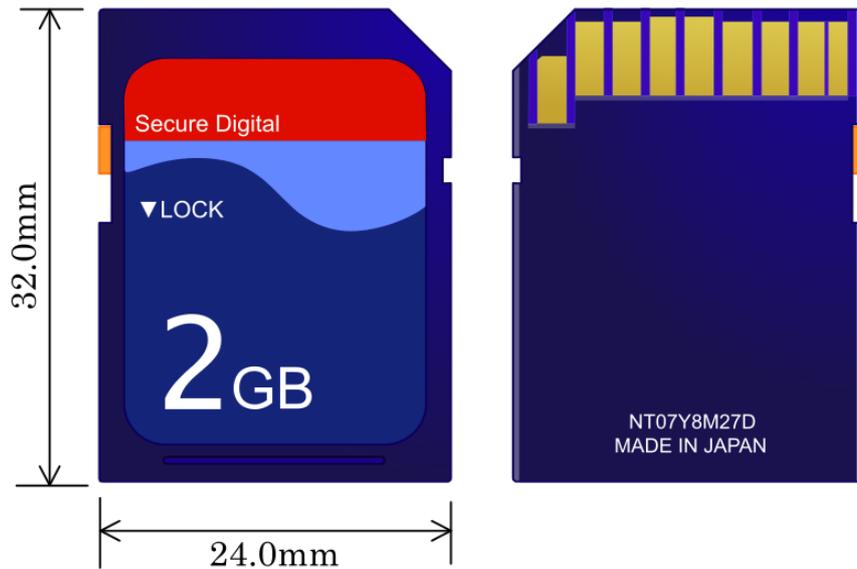
All SD and microSD cards use small brass contacts on the bottom of the card to send and receive info, via instructions and data.



## SD cards: Typical Use Cases and Dimensions

### Size

SDs are larger than microSD cards and measure 1.26 x 0.94 x 0.083 to 0.055 inches or 32 x 24 x 2.1-1.4 mm



Where are they used?

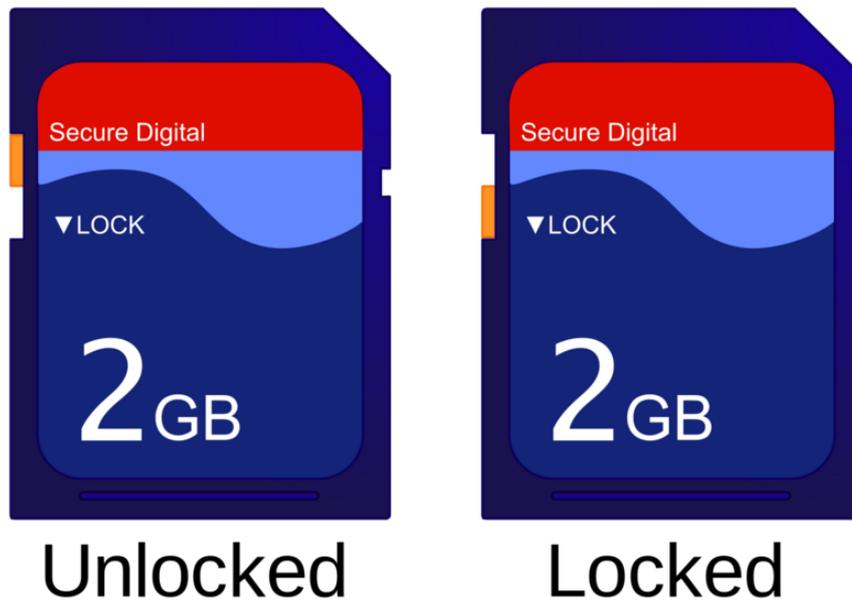
Most SD cards are used in [DSLR \(https://adafru.it/UTB\)](https://adafru.it/UTB) cameras, video game consoles, home theater devices like Blue-ray players, Internet of Things devices like security cameras, [and others \(https://adafru.it/UTC\)](https://adafru.it/UTC). Many other devices that used SD cards in the past such as smartphones, have transitioned over to the smaller microSD format.



### The locking toggle

SD cards have a mechanism on them that allows them to be "locked" and "unlocked". This toggle enables or disables the ability to write or delete data on the card.

This feature is useful when you want to prevent the files from being changed in any way. One example is if you fill an entire SD card with images from a trip, you could lock it to prevent accidentally taking more and overriding any photos.



microSD cards: Dimensions and use cases:

#### Size

0.56 x 0.43 x 0.039 inches or 15 x 11 x 1 mm



#### Use cases

microSD cards cover just about all other use cases. These include but are not limited to:

- Drones
- Smartphones
- Go Pros, [Point and Shoot cameras \(https://adafru.it/UTD\)](https://adafru.it/UTD), and other compact cameras

- Tablets
- Many other mobile devices!

### The locking toggle

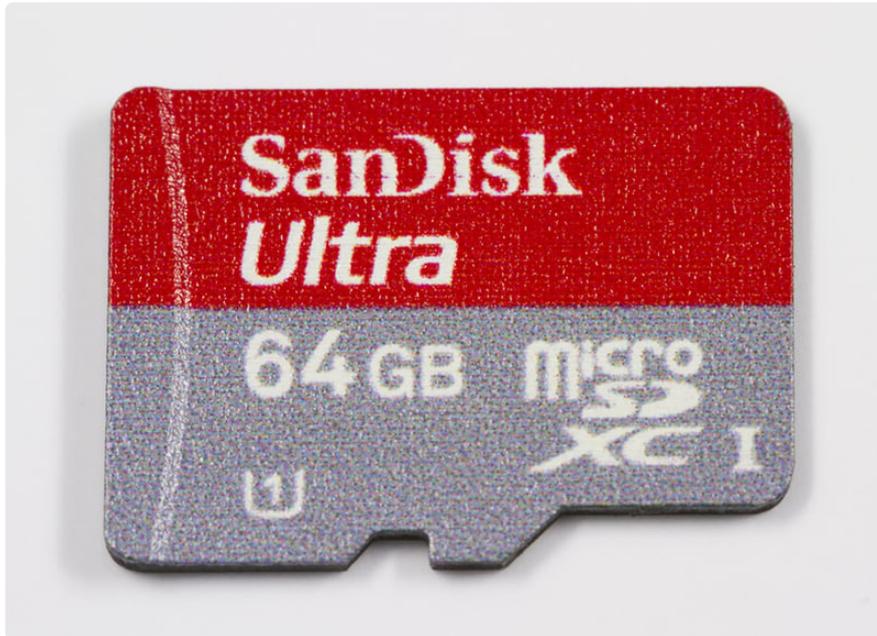
microSD cards do not inherently have this physical feature however if they are used with an adapter, this feature can be accessed.



Now that we know the main differences between SD and microSD cards, it's time to delve into the markings you may see on each card and how to determine what they all mean!

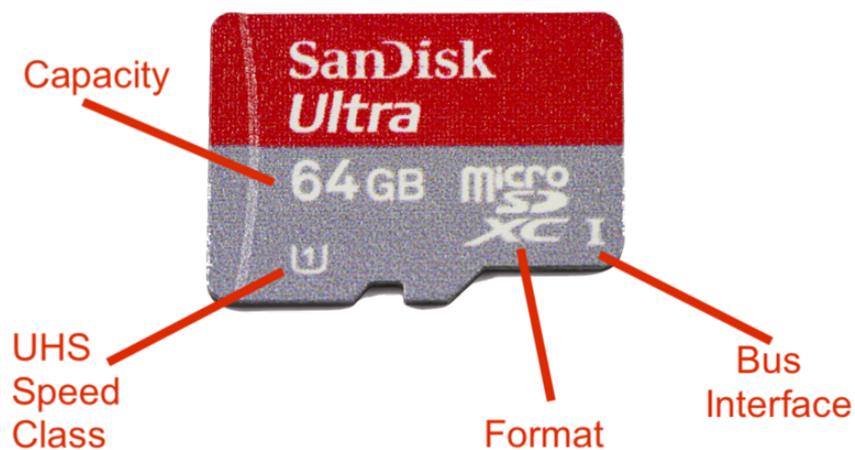
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## Markings: speed, size and class



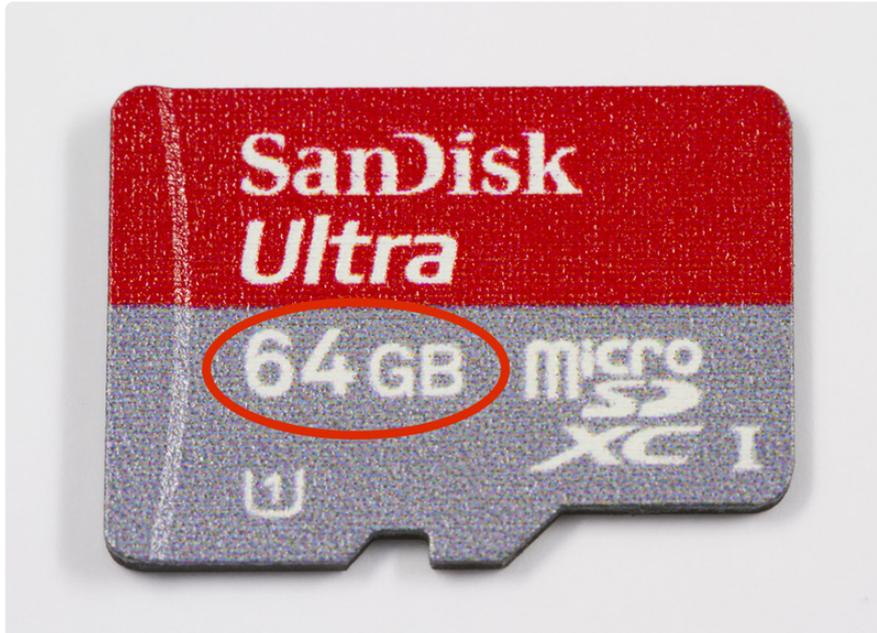
There are a number of different markings that may or may not be found on any given SD or microSD card. The markings help the user determine which purpose the card is best suited for among other information including:

- Memory capacity
- Minimum read and write speed
- Various read and write speed information



## Memory Capacity

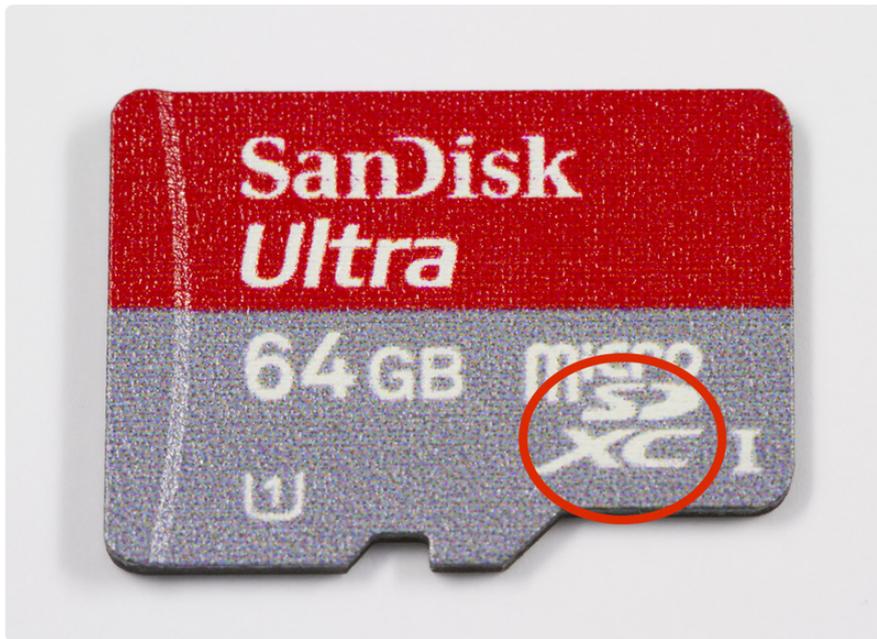
Most cards will display the memory capacity as a number on the card prominently, typically as Gigabytes (GB). However, they can be in Megabytes (MB), though it is not as common. The below example card is 64 GB.



## Format

There are four types of memory markings that represent the memory range or "format" for a card (in most cases):

- SD or **SDSC** (Standard Capacity) which means the card can have a **maximum of 2GB** (but could be less)
- **SDHC** (High Capacity) - the card **ranges from 2 to 32 GB**
- **SDXC** (Extended Capacity) - card **ranges from 32 GB to 2 Terabytes**
- **SDUC** (Ultra Capacity) - card **ranges from 2 to 128 TB** (not common)



## Speed Classes

There are 3 main different types of speed classes. [The SD association created this speed classification system \(https://adafru.it/UTd\)](https://adafru.it/UTd) to help determine what cards are best suited for various purposes. They all represent the same metric of a given card which is **the minimum read and write speed of a card in MB/s (Megabytes per second)**. A card can have 1 or more of these markings but typically has no more than 1.

### 1. Speed Class

One marking you may see on an SD card is the **speed class** marking. This class is at the lower end of the speed spectrum. This marking usually comes in the form of a number in a circle (as shown below) and represents the minimum read and write speed of the card in MB/s (**Megabytes per second**). This class can come as a 2, 4, 6, or 10.

A class 6 card can generally be used to film in HD and shoot basic JPEGs.

A class 10 card can be used for burst shooting, full HD, some 4K filming, and raw photography.

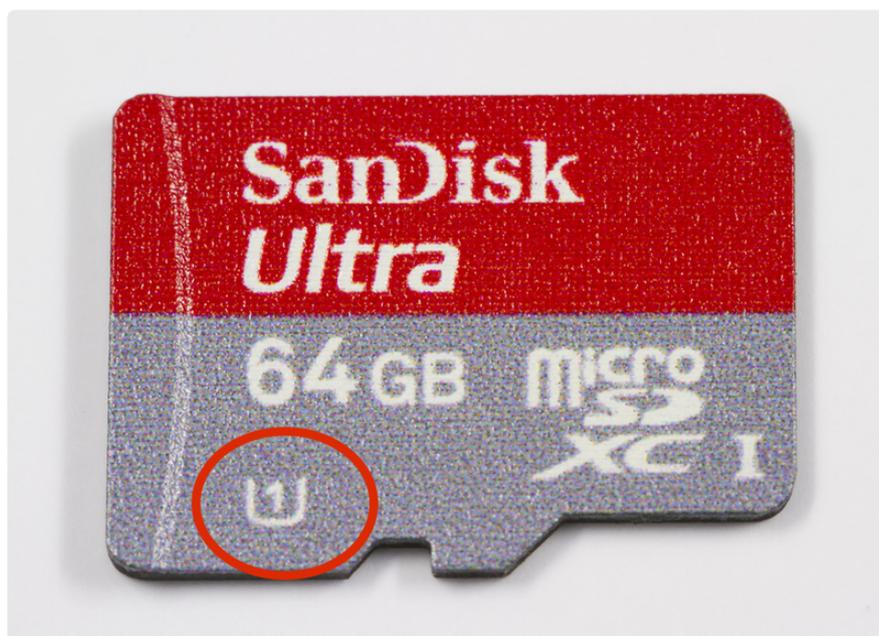


## 2. UHS (Ultra High) Speed Class

The next speed class up is called UHS. Again, this symbol represents the minimum read and write speed of a card. It is printed with a number inside of a U and has two variants:

- Class 1: 10 MB/s (equivalent to speed class 10)
- Class 3: 30 MB/s

[Many 4K cameras won't accept SDs without a UHS class 3 rating \(https://adafru.it/UTE\)](https://adafru.it/UTE). The UHS class 3 rating is generally a minimum requirement for ultra-high resolution filmmaking.



### 3. Video Speed Class

The last and highest reaching speed class is called the video speed class.

This class has the following variants:

- V6: 6 MB/s
- V10: 10 MB/s
- V30: 30 MB/s
- V60: 60 MB/s
- V90: 90 MB/s

V60 and V90 speeds are often needed for filming in 8K.



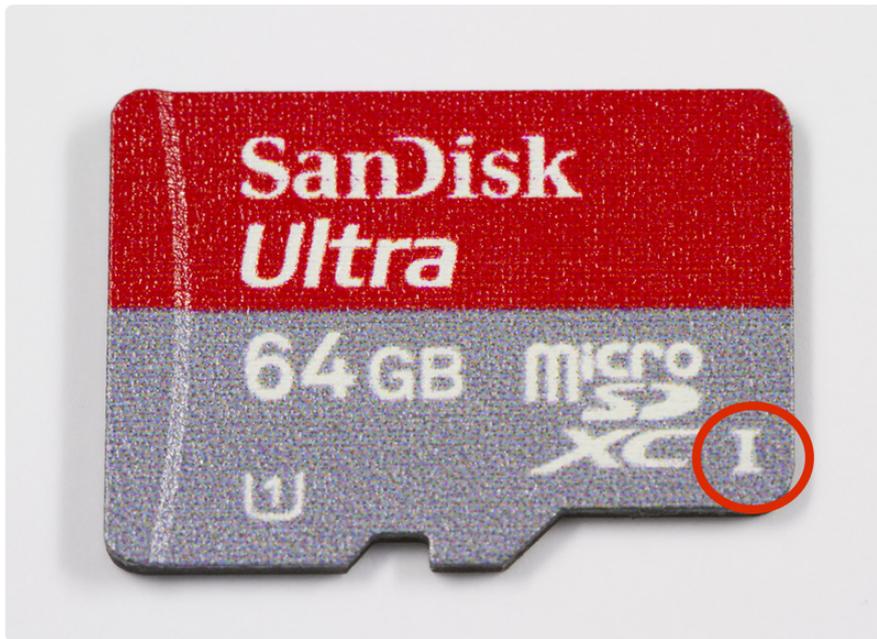
Comparison of SD card Speed Class ratings<sup>[109]</sup>

Minimum sequential writing speed	Suggested max. bitrate	Speed Class			Video format <sup>[a]</sup>				
		Speed Class	UHS Speed Class	Video Speed Class	SD	HD/Full HD	4K	8K	
2 MB/s	15 Mbit/s	Class 2 (C2)	N/A	N/A	Yes	No	No	No	
4 MB/s	30 Mbit/s	Class 4 (C4)	N/A	N/A		Yes	Yes	Yes	Yes
6 MB/s	45 Mbit/s	Class 6 (C6)	N/A	<b>V6</b> Class 6 (V6)					
10 MB/s	75 Mbit/s	Class 10 (C10)	Class 1 (U1)	<b>V10</b> Class 10 (V10)	Yes	Yes	Yes	Yes	
30 MB/s	220 Mbit/s	Class 10 (C10)	Class 3 (U3)	<b>V30</b> Class 30 (V30)					
60 MB/s	460 Mbit/s	Class 10 (C10)	Class 3 (U3)	<b>V60</b> Class 60 (V60)				Yes	
90 MB/s	700 Mbit/s	Class 10 (C10)	Class 3 (U3)	<b>V90</b> Class 90 (V90)				Yes	

## Bus Speed Class

Another speed class that is helpful to know (but not always necessary to know) is the **Bus Speed Class**. Each bus speed category is generally determined by the **peak bus throughput**. This is the **maximum** amount of bytes per second that can be exchanged between the host device and the SD card. Categories include:

- Default speed (DS): 12.5 MB/s
- High Speed (HS): 25 MB/s
- Ultra-high speeds:
  - Ultra-High Speed I (UHS-I): 50-104 MB/s
  - Ultra-High Speed II (UHS-II): 156 - 312 MB/s
  - Ultra-High Speed III (UHS-III): 213 - 624 MB/s
- SD Express:
  - 985 - 1969 MB/s
  - 1969 - 3964 MB/s



Only one set of contacts are used to send and receive information in UHS-I, so the bus will run in what is called Half Duplex mode when at a higher speed. This means at any given time, the SD card will only be able to send **or** receive data.

UHS-II and III contain extra contacts, which allows Full Duplex (send **and** receive together), to both occur simultaneously. Though, in UHS-II this results in the bus being made to run at a slower speed. UHS-III and SD Express don't have this problem and always run Full Duplex.

## Random Read Performance

An important key to measuring consistent system performance is the ability to handle lots of random data instructions (measured in IOPs, input/output operations per second). In 2015 the SD Association created two further standards: [Application Class A1 and A2 \(https://adafru.it/UTe\)](#). Cards with this rating will have an "A1" or an "A2" visibly printed.

- A1
  - Random read performance: 1500 IOPs
  - Random write performance: 500 IOPs
  
- A2
  - Random read performance: 4000 IOPs
  - Random write performance: 2000 IOPs

Very distinct hardware support is required for A2-rated cards. Lastly, a card that is rated A1 or A2 also entails that the write and read speed also has a video speed rating of at least V10 (10 MB/s minimum read and write speed).

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## Finding the right SD for you

Now that we know how to decipher all the markings on an SD, it's time to determine which SD or microSD is right for you.

### For Raspberry Pi

Raspberry Pi OS (formerly Raspbian), [Raspberry Pi's operating system \(https://adafru.it/UTF\)](https://adafru.it/UTF), can usually fit on an 8GB SD card, so you should have one that is this size at a minimum. However, if you would like more space, a 16 GB microSD definitely wouldn't hurt! For speed, class 10 (10 MB/s minimum read and write) is more than good enough. Lastly, while older boards used an SD card, modern Pis only take microSD cards.



#### [SD/MicroSD Memory Card \(8 GB SDHC\)](https://www.adafruit.com/product/1294)

Add mega-storage in a jiffy using this 8 GB class 4 micro-SD card. It comes with a SD adapter so you can use it with any of our shields or adapters. Preformatted to FAT so it works out...

<https://www.adafruit.com/product/1294>



#### [SD/MicroSD Memory Card - 16GB Class 10 - Adapter Included](https://www.adafruit.com/product/2693)

Add speedy mega-storage in a jiffy using this 16 GB Class 10 micro-SD card. It comes with a SD adapter so you can use it with any of our shields or adapters! Preformatted to FAT so it...

<https://www.adafruit.com/product/2693>

Check out the below guides for a deeper dive into preparing an SD card for your Pi.

### Guide: Preparing an SD Card for your Pi

<https://adafru.it/dDL>

### Official Raspberry Pi Getting Started Guide

<https://adafru.it/UUa>

## For Microcontrollers

microSD cards and microcontrollers go together like micro-peanut butter-and-jelly: SD cards are inexpensive, durable, easy to find at any shop, come in many sizes, and can plug into any computer using a common SD card reader. That makes them perfect for microcontroller storage and retrieval - whether it's images, fonts, GIFs, audio files, or sensor logs.

Any SD card that is 4-16GB should do the trick for these boards. The same 8GB and 16GB cards above will work great here.

Check out this guide for tips on how to use SD card breakouts with your microcontroller to expand its storage capacity. The guide also covers the `sdcario` (SPI based) and `sdioio` (SDIO based) CircuitPython libraries needed to interface with your SDs.

### Guide: microSD SPI or SDIO Card Breakout Board

<https://adafru.it/UUb>

## CircuitPython boards

With small CircuitPython and MicroPython boards, you typically have a very limited amount of flash memory to store code and data. Wouldn't it be nice if you could connect a microSD card to a Python board and expand its storage?

Check out the below guide on how to use SDs with CircuitPython based microcontroller boards

### Guide: CircuitPython Hardware: SD Cards

<https://adafru.it/Qfr>

## Basic Audio Recording and Low-Resolution SD video

These can be done with a class 2 or 2 MB/s read and write speed card.

## Consumer Point and Shoot Cameras

Basic point and shoot cameras can usually do fine with a class 4 or 4 MB/s read and write speed card.

## Filming HD, Shooting basic JPEGS, and Smart Phones

These tasks can be accomplished with an SD card that is at least class 6 or higher. Class 6 equates to a minimum of 6MB/s read and write speed. Make sure to choose a storage capacity that can fit your needs!

## Burst Shooting, Full HD, and Raw Photography

These activities need a beefier SD with a high speed class. That would be at least speed class 10 which is 10MB/s minimum read and write speed.

## 4K and Drone Filming

Most 4K cameras won't accept SDs without a UHS class 3 rating. That means a minimum of 30MB/s which is the same as a V30 Video Speed.

## 8K Filming

For ultra-high-resolution filmmaking, an SD card of at least V60 or V90 is highly suggested. This means a minimum of 60 or 90MB/s.

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## Pitfalls

With all these different cards, markings, and host devices, it can be easy to get lost in the sauce and buy a card that is not compatible with your device. Read below to avoid this situation!

Always make sure to check out the specifications of a device before purchasing an SD card for it

## Pitfall #1: You didn't check the device specifications

Always check the specifications of your device before buying an SD card for it. This will save you lots of time and headaches. You will be able to plan for buying the correct SD card using the info from this guide once you know the requirements of your device. See the example below for a practical lesson.

## Pitfall #2: Your SD card is not compatible with your device

If you have a device that requires a speed class 10 card and you give it a class 6 card, the device will not be able to use the card, it will be incompatible. However, if your device requires at least a class 6 card, you may use the class 10 card as most devices are backwards compatible. **Generally, you should use a card with the same class and specifications that the host device manual has specified.**

## Pitfall #3: Your SD card is too large

Many devices don't support more than 64GB. Again check the requirements of your device, specifically the memory limitations.

## Example: how to avoid purchasing the wrong SD card

This example was taken from the [SD guide by Tom's Tech Time \(https://adafru.it/UTE\)](https://adafru.it/UTE).

You have a typical drone, say the DJI Phantom 4 pro, for which you would like to buy the right SD card. You read the SD card requirements and find **the drone films in 4k at 100 megabits /sec**. Knowing this, what kind of SD card would you need?

- 8 Bits = 1 Byte
- 100 MBPS / 8 = 12.5 MB/s

Thus you would need a card with a minimum of 30MB/s. This equates to UHS class 3 or Video Speed class V30 rating. Solved!

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## Adapters, extenders, hubs and more

These gadgets allow you to wield your SDs with real power and will help you overcome barriers along the way.

Sometimes you may not be able to access your SD or microSD in the way you would like. For these cases, there are several options to access your precious data.

## Extenders

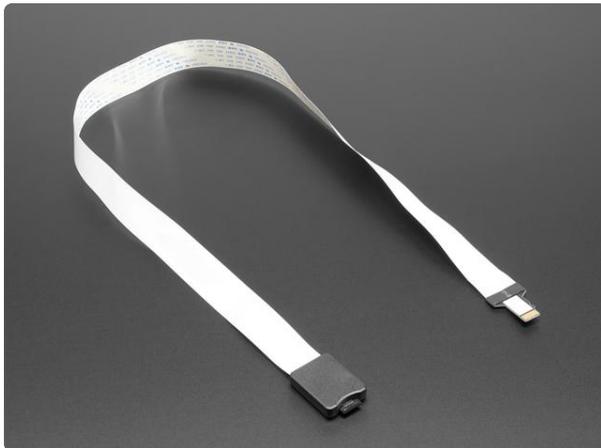
SD and micro SD sockets can often be hard to reach. These extenders allow you to reach the sockets and plug them into wherever you'd like.



### SD Card Extender

Stop fiddling with SD card sockets in the back of your latest gadget, and streeeeeeeeetch out with an SD Card Extender . This simple, but effective device gives...

<https://www.adafruit.com/product/3687>



### Micro SD Card Extender - 68cm (26 inch) long flex cable

Stop fiddling with SD card sockets in the back of your latest gadget, and streeeeeeeeetch out with a Micro SD Card Extender . This simple, but effective device...

<https://www.adafruit.com/product/3688>

## The micro SD card "wallet"

This handy cardholder gives a place for all your microSD cards to live (or sleep?)



### DiMeCard 8 microSD Card Holder

Mary Poppins had her TARDIS-like carpet bag. 90s kids had their Pokémon card binders. But we have the next best thing: DiMeCard, a super-slim 8-piece...

<https://www.adafruit.com/product/3664>

### SD card hubs

These are great when trying to read SDs into a computer. Many computers have been slimmed down to not include an SD card reader so these hubs let you read with ease. A simple "SD card hub" search on the web should get you some top-notch products.



### microSD to SD adapter

When you need to read a microSD card but your computer or hub only allows SD cards, you can grab one of these handy adapters.



### [SD/MicroSD Memory Card \(8 GB SDHC\)](https://www.adafruit.com/product/1294)

Add mega-storage in a jiffy using this 8 GB class 4 micro-SD card. It comes with a SD adapter so you can use it with any of our shields or adapters. Preformatted to FAT so it works out...

<https://www.adafruit.com/product/1294>

### MicroSD USB adapter

This handy adapter lets you go through USB to your computer, skipping the SD adapter altogether. Handy!



### [USB MicroSD Card Reader/Writer - microSD / microSDHC / microSDXC](https://www.adafruit.com/product/939)

This is the cutest little microSD card reader/writer - but don't be fooled by its adorableness! It's wicked fast and supports up to 64 GB SDXC cards! Simply slide the card into...

<https://www.adafruit.com/product/939>

## Formatting an SD card

Most operating systems like SD cards to be formatted in [exFAT \(https://adafru.it/UUc\)](https://adafru.it/UUc). Sometimes you may need to reformat your SD cards. To do this you can use this handy software provided by the SD association.

[Software download: SD card formatter](https://adafru.it/FKd)

<https://adafru.it/FKd>

Back up any data stored on an SD or microSD card prior to reformatting it so your data is safe.

Some other OSES and devices require other SD formats, so make sure to read up on the formatting requirements.

That's it! You are an SD expert at this point. There's always more to learn but at least now you can go out there and purchase with confidence. Bon voyage!