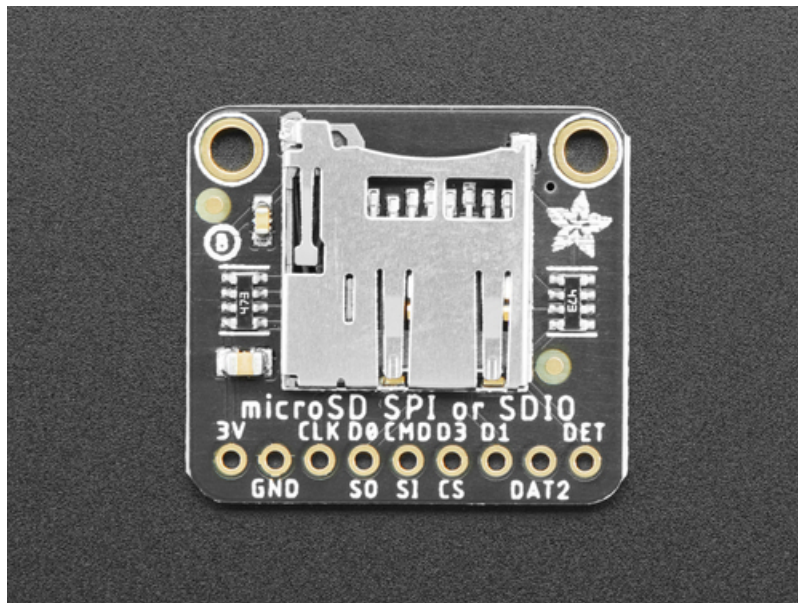


Adafruit MicroSD SPI or SDIO Card Breakout Board

Created by Jeff Epler

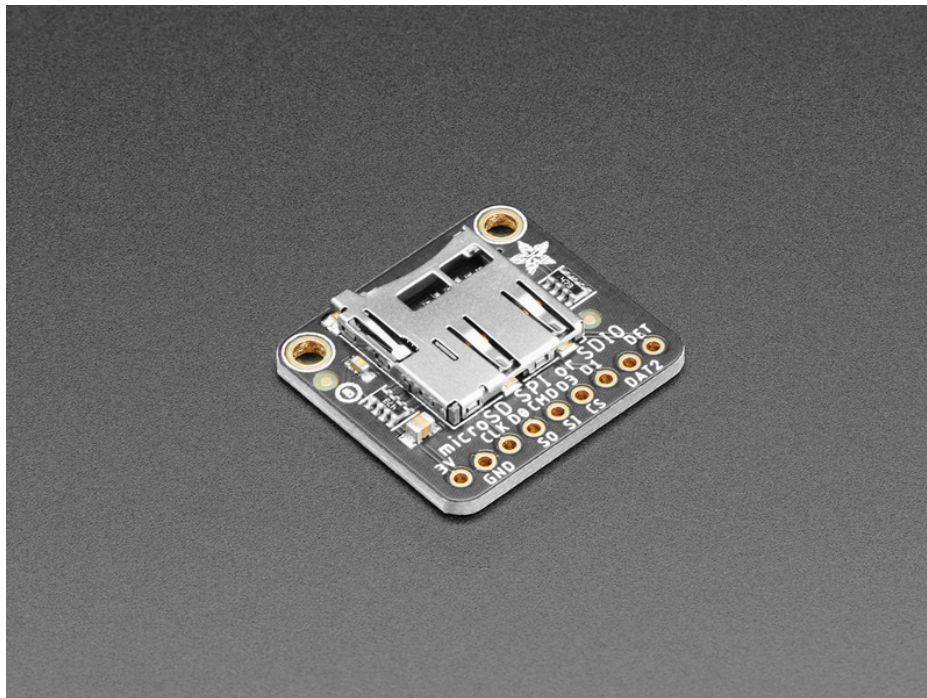


Last updated on 2021-03-24 11:06:08 AM EDT

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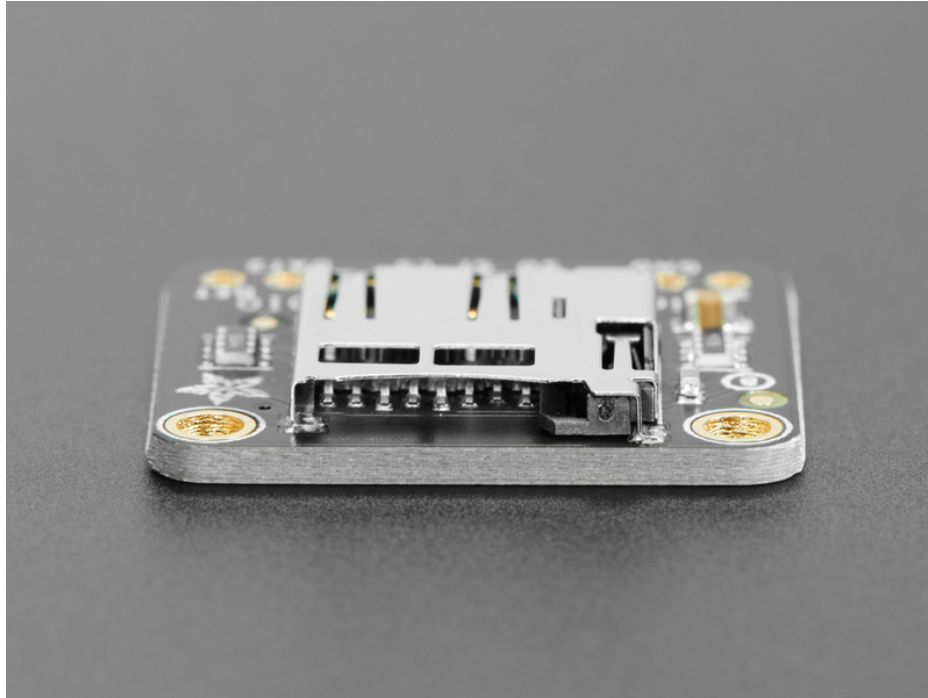
Overview



Micro SD cards and microcontrollers go together like micro-peanutbutter-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.

Wiring up SD cards when you're starting out is super easy - you just [pick up one of Adafruit's SPI-to-SD breakout boards \(https://adafru.it/qyF\)](https://adafru.it/qyF), [wire it to an SPI port and a chip select pin and with a little library work you're reading and writing files \(https://adafru.it/Myb\)](https://adafru.it/Myb). That's all good and great but you may eventually find that your SD card project is a little...slow. **Even with fast SPI ports, there's only one data pin, which can make it hard to stream large files fast.**

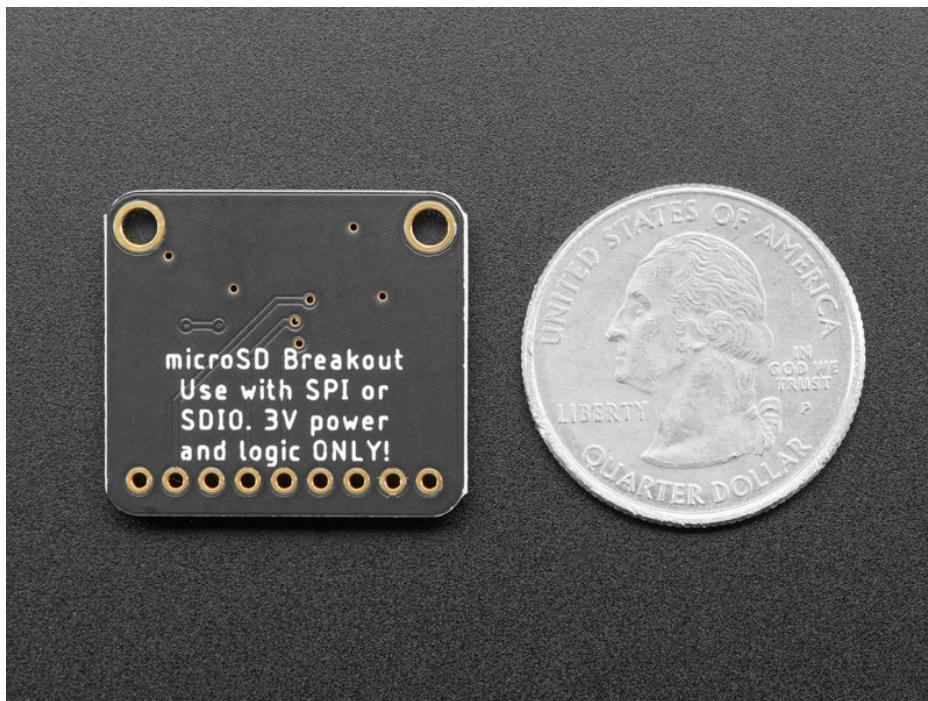
If you've hit that limit, [this new breakout \(https://adafru.it/Mzd\)](https://adafru.it/Mzd) is designed to help. Unlike previous adapters, it is not fixed for SPI usage, and can be used with SDIO hardware support. SDIO is a multi-pin data protocol (up to 4 data pins at once!) SDIO also tends to be able to be clocked faster than SPI. Of course, your speeds will vary depending on what microcontroller you hook it up to. When we used SDIO instead of SPI on CircuitPython with the [SAM D51 Grand Central \(https://adafru.it/grandc\)](https://adafru.it/grandc), we got a speed increase of about 200% when reading data off the card



You will need to verify that your microcontroller has SDIO support and you have SDIO firmware/library support as well. SDIO is usually available on higher end chips, and you may need to use some specific pins. You can *still* use this for SPI mode, but it does not have level shifters, so it's not for use with 5V microcontrollers.

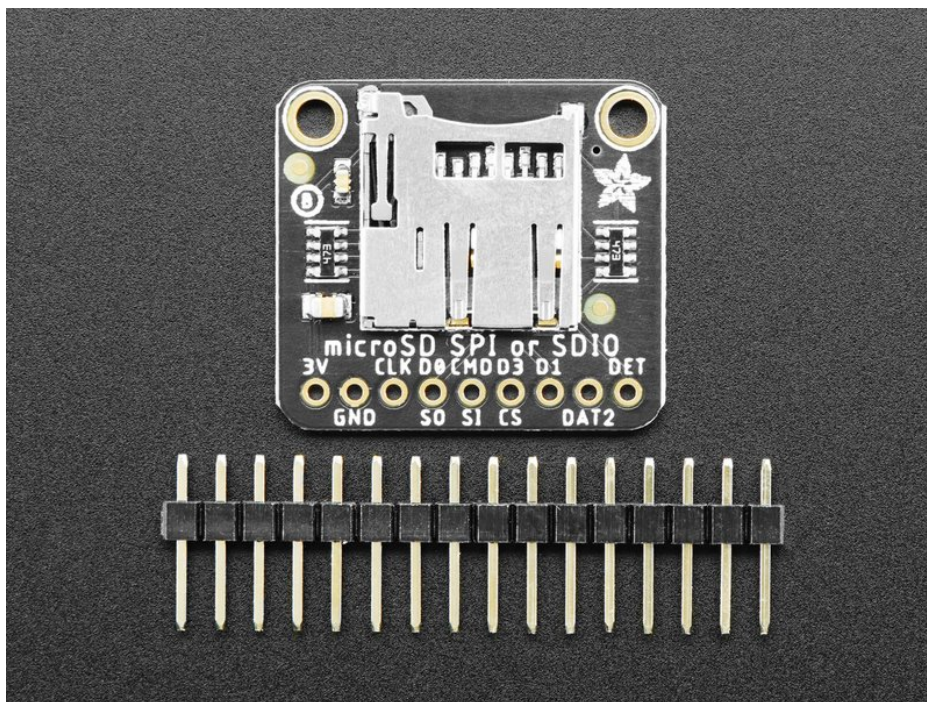
For use with 3V power and logic microcontrollers only! The SDIO pins are bi-directional, and we've never seen a 5V microcontroller with SDIO, so there's no level shifting or power regulator.

The breakout comes with a bit of header so you can use in a breadboard. It doesn't come with the micro SD card itself!



[Secure Digital \(https://adafru.it/rye\)](https://adafru.it/rye), or SD, cards and tiny microSD cards are an inexpensive and ubiquitous means of adding lots of storage to devices. For a few dollars you can have gigabytes of storage at your fingertips (smaller than your fingertips actually!). With CircuitPython 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? It turns you can use microSD cards with CircuitPython! In fact some boards like the Metro M4 Grand Central come with microSD card support built-in, and for other boards like the Feather M4 Express family they can easily be connected to a microSD card that expands their storage.



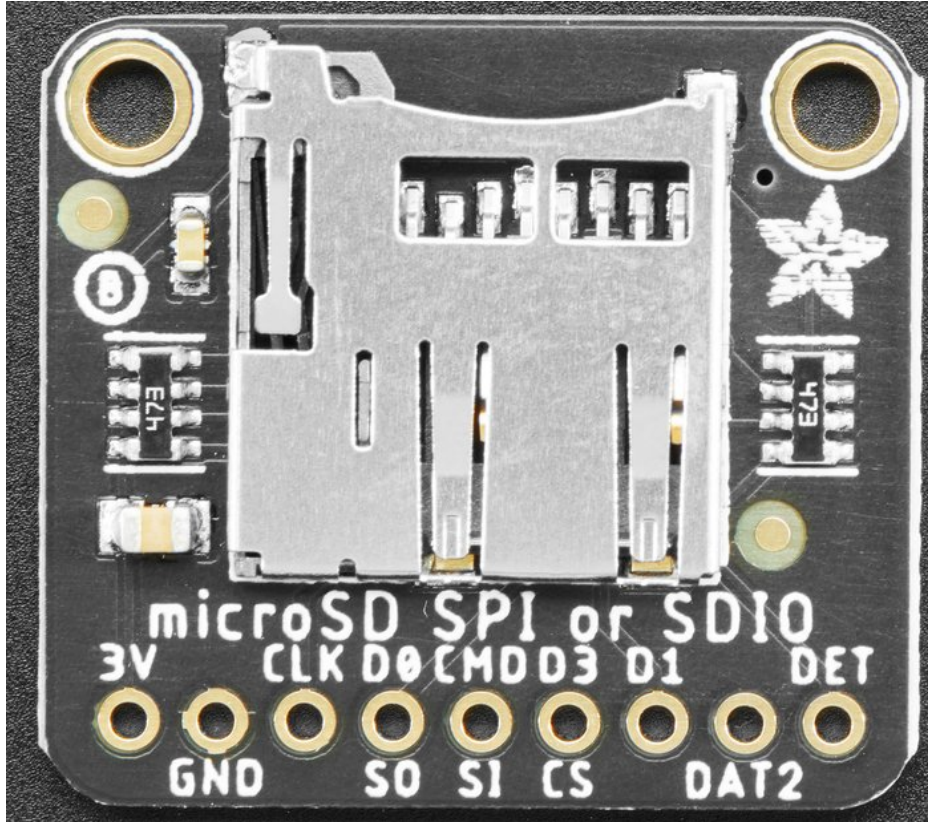
With the Adafruit MicroSD SPI or SDIO Card Breakout Board, you can add an SD card to your project using the common SPI interface or the higher performance SDIO interface.

This guide also shows how to use a microSD card to store files for a CircuitPython board. Specifically using a microSD card with CircuitPython boards like Feather M0 Adalogger, Grand Central M4, ItsyBitsy M4, and others will be covered in this guide. You'll learn how to connect a microSD card to the board and mount it as a new filesystem that store code & data.

Starting with CircuitPython 6, there are two new modules to improve the performance of SD cards using SDIO.

Make sure you're running CircuitPython 6.0 or later, including pre-releases. These modules aren't available in older versions. Remember, you can always downgrade to the stable version of CircuitPython if necessary.

Pinouts



Power Pins

- **3V** - This is the power pin. MicroSD cards must use 3.3V, so take care to only hook 3.3V to this pin. Hooking 5V or VBAT to this pin will damage your microSD card.
- **GND** - common ground for power and logic.

Common Logic Pins

- **DET** - Detect whether a microSD card is inserted. This pin is connected to **GND** internally when there's no card, but when one is inserted it is pulled up to **3V** with a 4.7k Ω resistor. That means that when the pin's logic level is **False** there's no card and when it's **True** there is.

SPI Logic Pins

If you're using SPI to connect to your SD cards, the pins have the following functions:

- **CLK** - This is the SPI Clock pin / **SCK** Serial Clock, its an input to the chip.
- **SO** - this is the **Serial Out / Microcontroller In Serial Out** pin, for data sent from the SD card to your processor.
- **SI** - this is the **Serial In / Microcontroller Out Serial In** pin, for data sent from your processor to the SD card. Its an input to the chip and can use 3 - 5V logic.
- **CS** - this is the **Chip Select** pin, drop it low to start an SPI transaction. Its an input to the chip and can use 3 - 5V logic.

Pull ups are provided on all SPI logic pins.

SDIO Logic Pins

If you're using SDIO to connect to your SD cards, the pins have the following functions:

- **CLK** - The SDIO clock pin. A clock signal is sent by the microcontroller to the SD card on this pin.
- **CMD** - A bidirectional pin for communication between the microcontroller and the SD card, used for commands and information.
- **4 Data pins** - Four bidirectional pins for communication between the microcontroller and the SD card, used for transferring bulk data. Take care to wire these in the correct order! The silk screen legends read: **D0, D1, DAT2, D3**.

Pull ups are provided on all SDIO logic pins.

Note that when inserted, the SD card extends slightly beyond the edge of the PCB. Check out the mechanical drawing on the [Downloads page \(https://adafruit.it/Qce\)](https://adafruit.it/Qce).

CircuitPython

Are you new to using CircuitPython? No worries, [there is a full getting started guide here \(https://adafru.it/cpy-welcome\)](https://adafru.it/cpy-welcome).

Adafruit suggests using the Mu editor to edit your code and have an interactive REPL in CircuitPython. [You can learn about Mu and installation in this tutorial \(https://adafru.it/ANO\)](https://adafru.it/ANO).

Preparing your SD card

If you bought an SD card, chances are it's already pre-formatted with a FAT filesystem. However you may have problems with how the factory formats the card, or if it's an old card it needs to be reformatted. CircuitPython supports both **FAT16** and **FAT32** filesystems.

It's **always** good idea to format the card before using, even if it's new! Note that formatting will erase the card, so save anything you want first.

We strongly recommend you use the official SD card formatter utility - written by the SD association. It solves many problems that come with bad formatting!

<https://adafru.it/FKd>

<https://adafru.it/FKd>

The official SD formatter is available from

<https://www.sdcard.org/downloads/formatter/> (<https://adafru.it/FKd>)

Download it and run it on your computer, there's also a manual linked from that page for additional instructions.

General Steps for Accessing SD Cards

The following pages will show all the steps to set up an SD card, including wiring information if applicable. They all follow the same general structure:

1. If necessary, create an **SPI** bus object connecting to the card (cards attached by SDIO do not have a separate bus object)
2. Construct an **SDCard** object
3. Create a **vfs** (virtual filesystem) object
4. "Mount" the **vfs** object to make the SD card's files appear so they can be accessed by functions like **open()**

Tip: Create a `mount_sd.py` file

If you put the exact lines necessary to mount the sd card in a separate Python file in **CIRCUITPY** as `mount_sd.py`, you can easily call it from the REPL or from `code.py` with **import**:

```
import mount_sd
```

In the examples, we'll assume you have already created a `mount_sd.py` file.

CircuitPython has trouble recognizing cards bigger than 32GB. 32GB of data with CircuitPython? That's a lot.

sdcardio: For SD cards on SPI interfaces

`sdcardio` is the module for SD cards that use an SPI interface. Unless otherwise noted, it's a good bet that a microcontroller SD card interface uses SPI. SPI uses 4 signal wires and can function at rates from 400kHz up to multiple MHz. Under some circumstances, multiple SPI devices can share 3 out of the 4 pins.

sdioio: For SD cards on SDIO interfaces

`sdioio` is the module for SD cards that use an SDIO interface. A few specific boards have SDIO interfaces available. SDIO uses at least 3 signal wires (CMD, CLK, and DATA0), but can use additional data wires (DATA1, DATA2, DATA3). SDIO operates at 25MHz or 50MHz, and it can transfer 1 or 4 bits at a time. However, in practice, it offers around 1.5 to 2x the speed of SPI when reading from an SD card.

The built in micro SD slot on the STM32F405 Feather is connected using SDIO. The Grand Central M4 can connect the SD card using SDIO or SPI, depending which pins are used.

adafruit_sdcard.py: For legacy uses

`adafruit_sdcard` is covered in [its own guide \(https://adafru.it/MA2\)](https://adafru.it/MA2). There are still some cases where you should use `adafruit_sdcard`:

- You're not ready to upgrade to CircuitPython 6
- Some boards without much capacity omit `sdcardio`, but you can put `adafruit_sdcard` in `CIRCUITPY`. This applies to all boards with the SAM D21 microcontroller.

Using sdcardio

sdcardio is an SPI interface SD card library in CircuitPython 6.0 that is optimized in C to be much faster than the original adafruit_sdcard library. Some much smaller/older boards don't have enough memory for this module, in which case you will have to use adafruit_sdcard

Use the code and wiring examples in this section if these conditions are met:

- Your SD card slot uses the SPI bus to connect to the microcontroller (If it uses SDIO, go to [the pages for sdioio](#) (<https://adafru.it/MA3>))
- Your CircuitPython board supports the `sdcardio` module. (If not, go to [the pages for adafruit_sdcard](#) (<https://adafru.it/MA4>))
- Your CircuitPython version supports the `sdcardio` module. Only CircuitPython 6 and newer have sdcardio. (If not, go to [the pages for adafruit_sdcard](#) (<https://adafru.it/MA4>))

If the same SPI bus is shared with other peripherals, it is important that the SD card be initialized before accessing any other peripheral on the bus. Failure to do so can prevent the SD card from being recognized until it is powered off or re-inserted.

The following section will show how to initialize the SD card and read & write data to it. You'll want to put the correct lines to initialize it in `mount_sd.py` on your **CIRCUITPY** drive. For specific wiring information and exact `mount_sd.py` files for several different boards, check out the following pages.

Initialize & Mount SD Card Filesystem

Before you can use the microSD card you need to initialize its SPI connection and mount its filesystem. First import all the modules we'll need:

```
import board
import busio
import sdcardio
import storage
```

Next create the SPI bus and a digital output for the microSD card's chip select line (be sure to select the right pin names for your wiring):

```
# Use the board's primary SPI bus
spi = board.SPI()
# Or, use an SPI bus on specific pins:
#spi = busio.SPI(board.SD_SCK, MOSI=board.SD_MOSI, MISO=board.SD_MISO)

# For breakout boards, you can choose any GPIO pin that's convenient:
cs = board.D10
# Boards with built in SPI SD card slots will generally have a
# pin called SD_CS:
#cs = board.SD_CS
```

Note that when you use `sdcardio`, `cs` is a `Pin` object, not a `DigitalInOut` object. If you change your code to

use `adafruit_sdcard`, you need to use a `DigitalInOut` object instead.

At this point you're ready to create the microSD card object and the filesystem object:

```
sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
```

Notice the `sdcardio` module has a `SDCard` class which contains all the logic for talking to the microSD card at a low level. This class needs to be told the SPI bus and chip select pin in its constructor.

After a `SDCard` instance is created it can be passed to the `storage` module's `VfsFat` class. This class has all the logic for translating CircuitPython filesystem calls into low level microSD card access. Both the `SDCard` and `VfsFat` class instances are required to mount the card as a new filesystem.

Finally you can mount the microSD card's filesystem into the CircuitPython filesystem. For example to make the path `/sd` on the CircuitPython filesystem read and write from the card run this command:

```
storage.mount(vfs, "/sd")
```

At this point, you can read and write to the SD card using common Python functions like `open`, `read`, and `write`. The filenames will all begin with `"/sd/"` to differentiate them from the files on the `CIRCUITPY` drive. If you're not familiar, here's an overview.

Reading & Writing Data

Once the microSD card is mounted inside CircuitPython's filesystem you're ready to read and write data from it. Reading and writing data is simple using Python's file operations like `open` (<https://adafru.it/reL>), `close` (<https://adafru.it/ryE>), `read` (<https://adafru.it/ryE>), and `write` (<https://adafru.it/ryE>). The beauty of CircuitPython and MicroPython is that they try to be as similar to desktop Python as possible, including access to files.

For example to create a file and write a line of text to it you can run:

```
with open("/sd/test.txt", "w") as f:
    f.write("Hello world!\r\n")
```

Notice the `with` statement is used to create a context manager that opens and automatically closes the file. This is handy because with file access you Python you **must** close the file when you're done or else all the data you thought was written might be lost!

The `open` function is used to open the file by telling it the path to it, and the mode (w for writing). Notice the path is under `/sd`, `/sd/test.txt`. This means the file will be created on the microSD card that was mounted as that path.

Inside the context manager you can access the `f` variable to operate on the file while it's open. The `write` function is called to write a line of text to the file. Notice that unlike a `print` statement you need to end the string passed to write with explicit carriage returns and new lines.

You can also open a file and read a line from it with similar code:

```
with open("/sd/test.txt", "r") as f:
    print("Read line from file:")
    print(f.readline(), end='')
```

When reading a line from a file with `readline`, the newline character `\n` at the end of the line is included. By printing with `end=""`, the newline normally added by `print` is skipped. Otherwise, when reading back the file, it would appear that there were extra blank lines after every line of the file.

If you wanted to read and print all of the lines from a file you could call `readline` in a loop. Once `readline` reaches the end of the file it will return an empty string so you know when to stop:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    line = f.readline()
    while line != '':
        print(line, end='')
        line = f.readline()
```

You can also just use the open file object in a `for` loop. Each time the loop runs, the loop variable will be assigned the content of the next line of the file:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    for line in f:
        print(line, end='')
```

Finally one other very common file scenario is opening a file to add new data at the end, or append data. This works exactly the same as in Python and the `open` function can be told you'd like to append instead of erase and write new data (what normally happens with the `w` option for `open`). For example to add a line to the file:

```
with open("/sd/test.txt", "a") as f:
    f.write("This is another line!\r\n")
```

Notice the `a` option in the `open` function--this tells Python to add data at the end of the file instead of erasing it and starting over at the top. Try reading the file with the code above to see the new line that was added!

Those are the basics to manipulating files on microSD cards with CircuitPython! Once you have it working, put the correct lines in `mount_sd.py` in **CIRCUITPY**, then continue learning by checking out the example pages to print directory listings, log sensor data, play MP3 files and display bitmap graphics.

Example complete `mount_sd.py`

This example works on the ItsyBitsy M4 Express together with the Adafruit MicroSD Breakout Board:

```
import board
import busio
import sdcardio
import storage

spi = board.SPI()
cs = board.D10

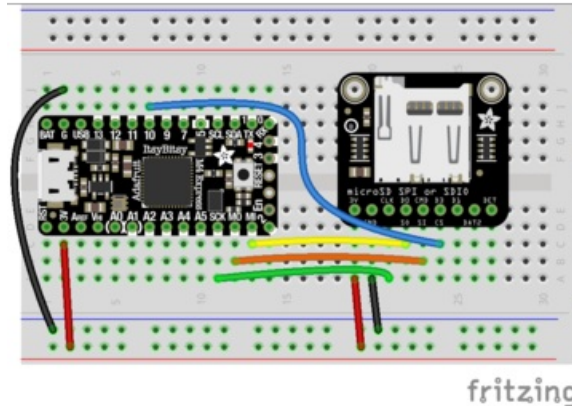
sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```

Your board may be different. Refer to the following pages for more details.

ItsyBitsy M4 Express + Breakout

sdcardio is an SPI interface SD card library in CircuitPython 6.0 that is optimized in C to be much faster than the original adafruit_sdcard library. Some much smaller/older boards don't have enough memory for this module, in which case you will have to use adafruit_sdcard

Ready to do a little wiring? Almost any Adafruit CircuitPython board will connect to the MicroSD Breakout Board using SPI. The following is an example using the Itsy Bitsy M4 express.



- Board 3V to breakout 3V via supply rail
- Board GND to breakout GND via supply rail
- Board MI (or MISO) to breakout SO
- Board MO (or MOSI) to breakout SI
- Board SCK to breakout CLK
- Board D10 to breakout CS

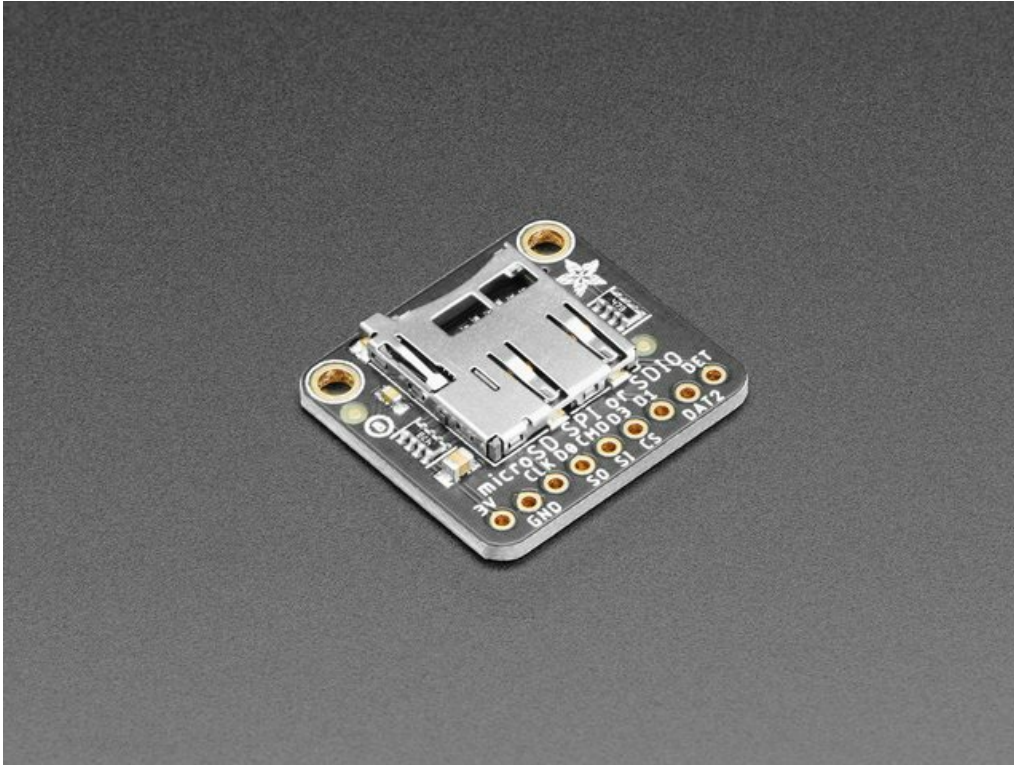
The example below uses D10, but you can use any available digital pin instead. Change the `mount_sd.py` code below to use the pin you selected instead of `board.D10`.

The ItsyBitsy and the MicroSD breakout are a great way to have SD card storage in a small footprint, but these instructions will work with just about any Adafruit Feather too. Just follow the fritzing diagram and then put the following in `mount_sd.py`:

```
import board
import busio
import sdcardio
import storage

spi = board.SPI()
cs = board.D10 # Use the pin you wired to the breakout CS

sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```



[Adafruit Micro SD SPI or SDIO Card Breakout Board - 3V ONLY!](#)

Micro SD cards and microcontrollers go together like micro-peanutbutter-and-jelly: SD cards are inexpensive, durable, easy to find at any shop, come in many sizes and can plug into any...

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[Adafruit ItsyBitsy M4 Express featuring ATSAMD51](#)

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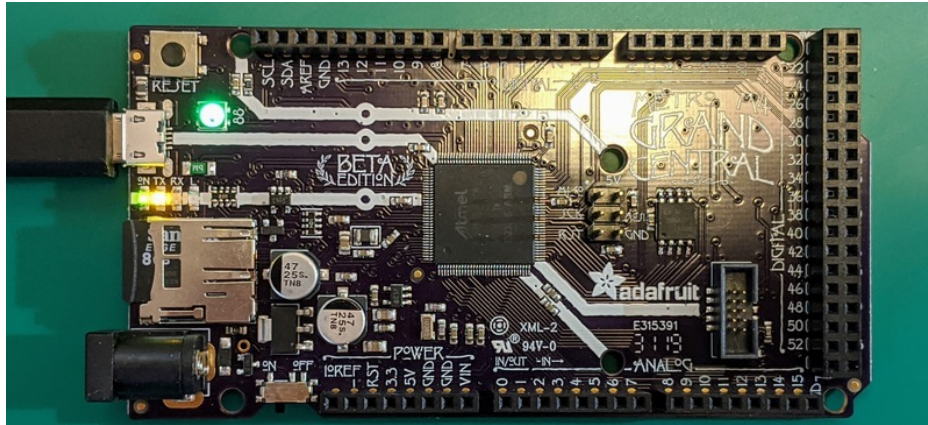
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Grand Central M4 Express

sdcardio is an SPI interface SD card library in CircuitPython 6.0 that is optimized in C to be much faster than the original adafruit_sdcard library. Some much smaller/older boards don't have enough memory for this module, in which case you will have to use adafruit_sdcard



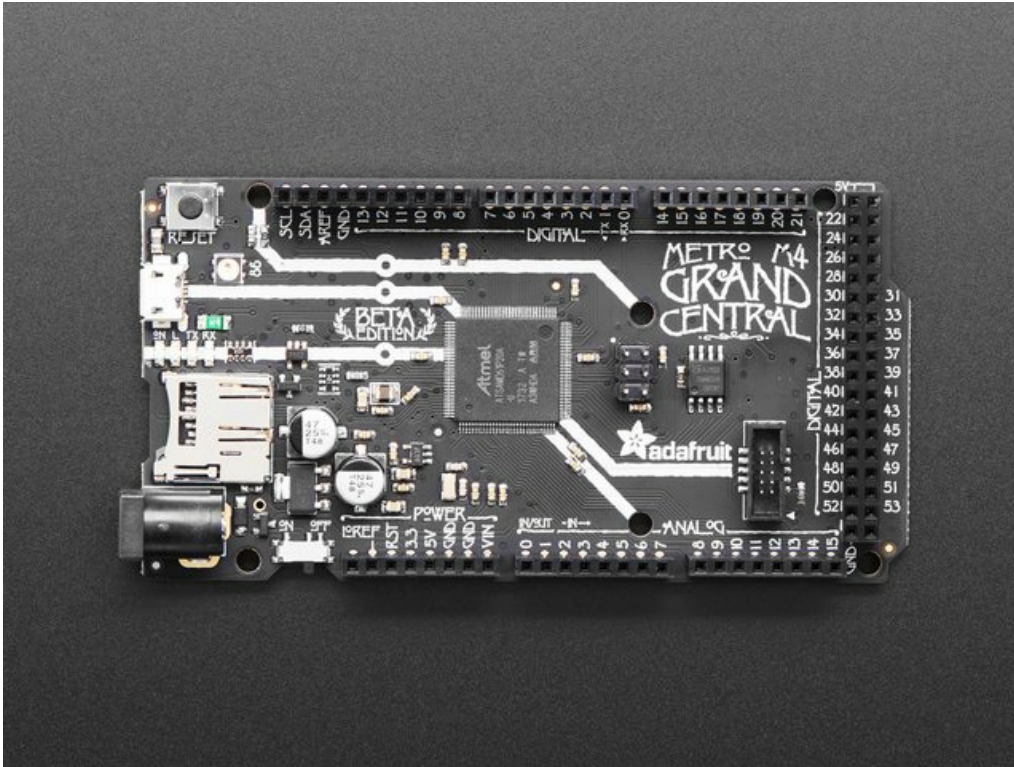
The Adafruit Grand Central M4 Express has a built-in SD card connected to the SPI bus, so no wiring or soldering is needed!

To mount the SD card, use the following code. Remember to put it in the file `mount_sd.py` on **CIRCUITPY** so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import board
import busio
import sdcardio
import storage

spi = busio.SPI(board.SD_SCK, MOSI=board.SD_MOSI, MISO=board.SD_MISO)
cs = board.SD_CS

sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```



Adafruit Grand Central M4 Express featuring the SAMD51

Are you ready? Really ready? Cause here comes the Adafruit Grand Central featuring the Microchip ATSAM51. This dev board is so big, it's not...

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PyGamer

sdcardio is an SPI interface SD card library in CircuitPython 6.0 that is optimized in C to be much faster than the original adafruit_sdcard library. Some much smaller/older boards don't have enough memory for this module, in which case you will have to use adafruit_sdcard

The PyGamer has a built-in SD card connected to a SPI bus, so no wiring or soldering is needed!

To mount the SD card, use the following code. Remember, to put it in the file `mount_sd.py` on **CIRCUITPY** so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import board
import sdcardio
import storage

spi = board.SPI()
cs = board.SD_CS

sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```



Adafruit PyGamer Starter Kit

Please note: you may get a royal blue or purple case with your starter kit (they're both lovely colors)What fits in your pocket, is fully Open...

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[Adafruit PyGamer for MakeCode Arcade, CircuitPython or Arduino](#)

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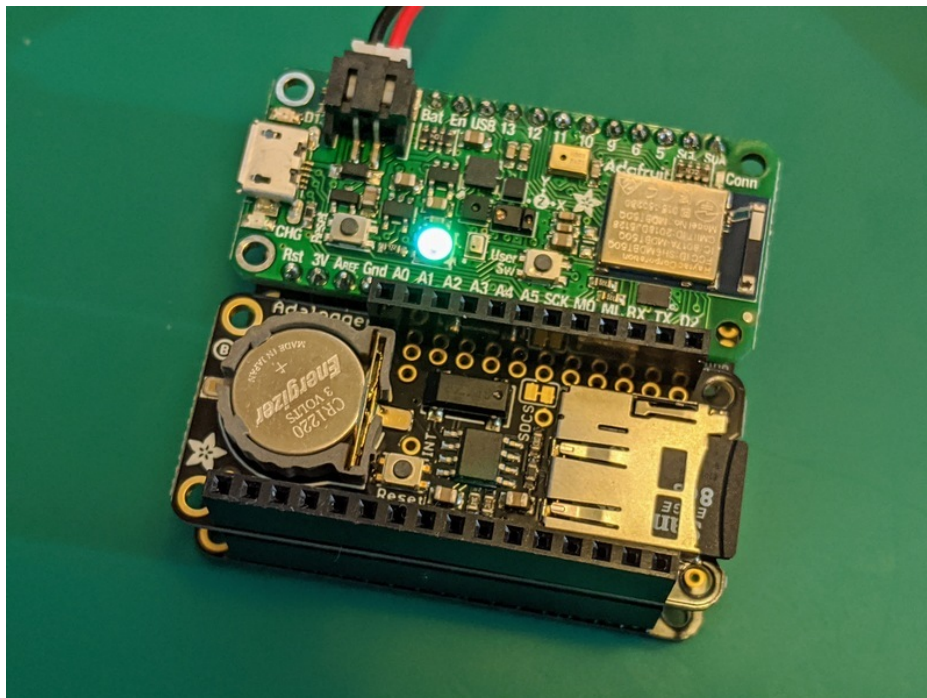
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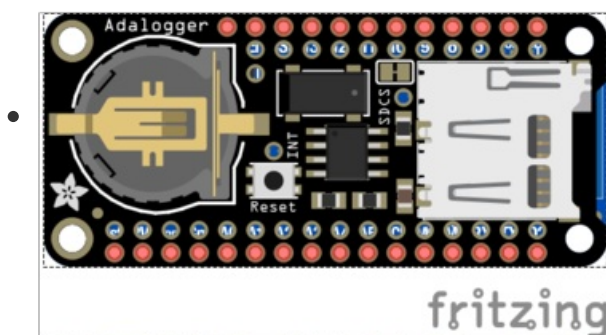
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Feather Sense + Adalogger FeatherWing

`sdcardio` is an SPI interface SD card library in CircuitPython 6.0 that is optimized in C to be much faster than the original `adafruit_sdcard` library. Some much smaller/older boards don't have enough memory for this module, in which case you will have to use `adafruit_sdcard`



With all its built-in sensors and battery power, the Feather M4 Sense is great for data-logging projects. Stacking headers or FeatherWing Doublers need a little soldering but no custom wiring.



- Plug the FeatherWing into the Feather.

You can also place them side by side on a FeatherWing Doubler.

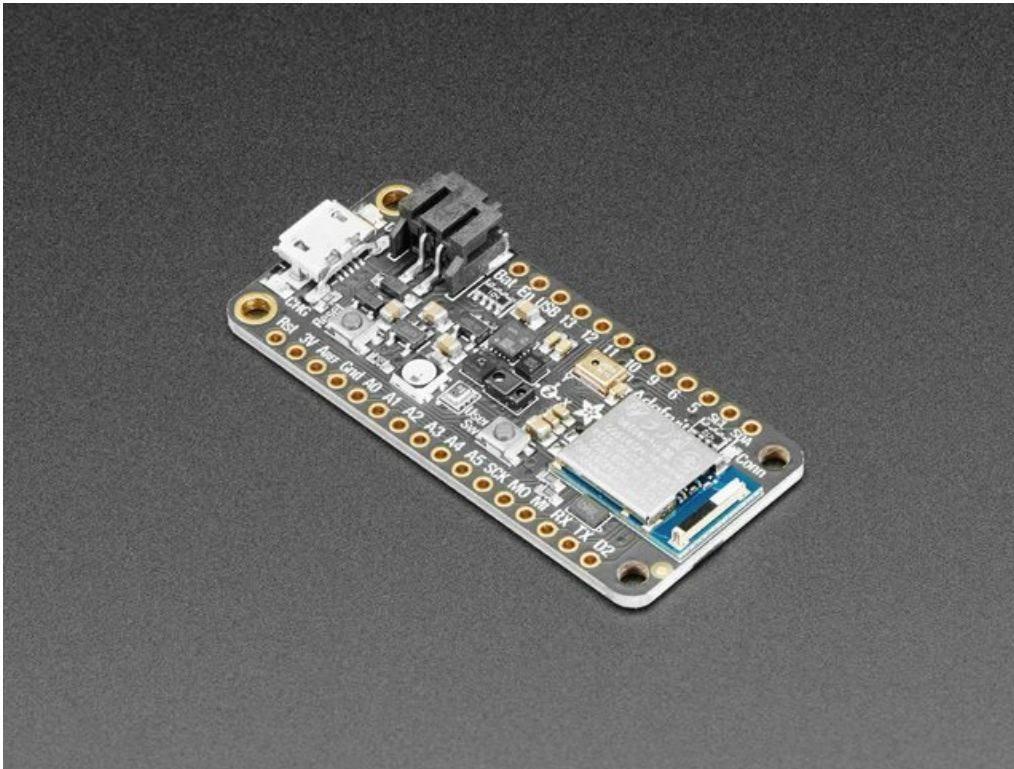
Don't forget that the Adalogger FeatherWing has a [Real Time Clock \(RTC\)](https://adafru.it/MA5) so you can even timestamp your logs!

To mount the SD card, use the following code. Remember, to put it in the file `mount_sd.py` on `CIRCUITPY` so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import board
import busio
import sdcardio
import storage

spi = board.SPI()
cs = board.D10

sdcard = sdcardio.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```



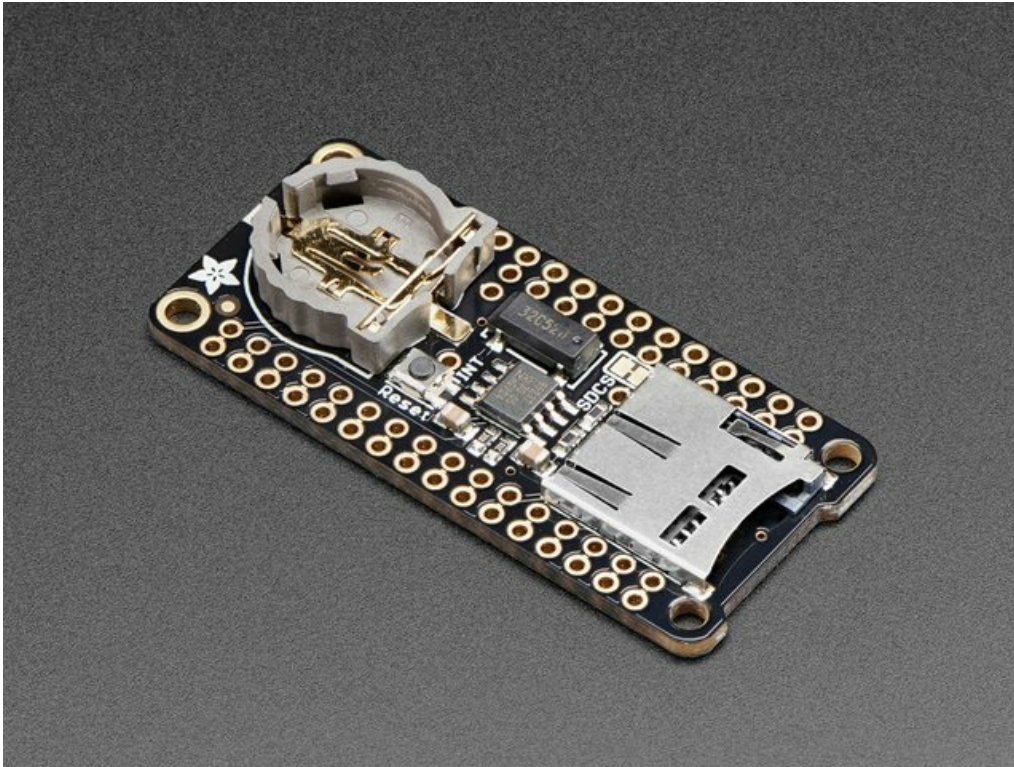
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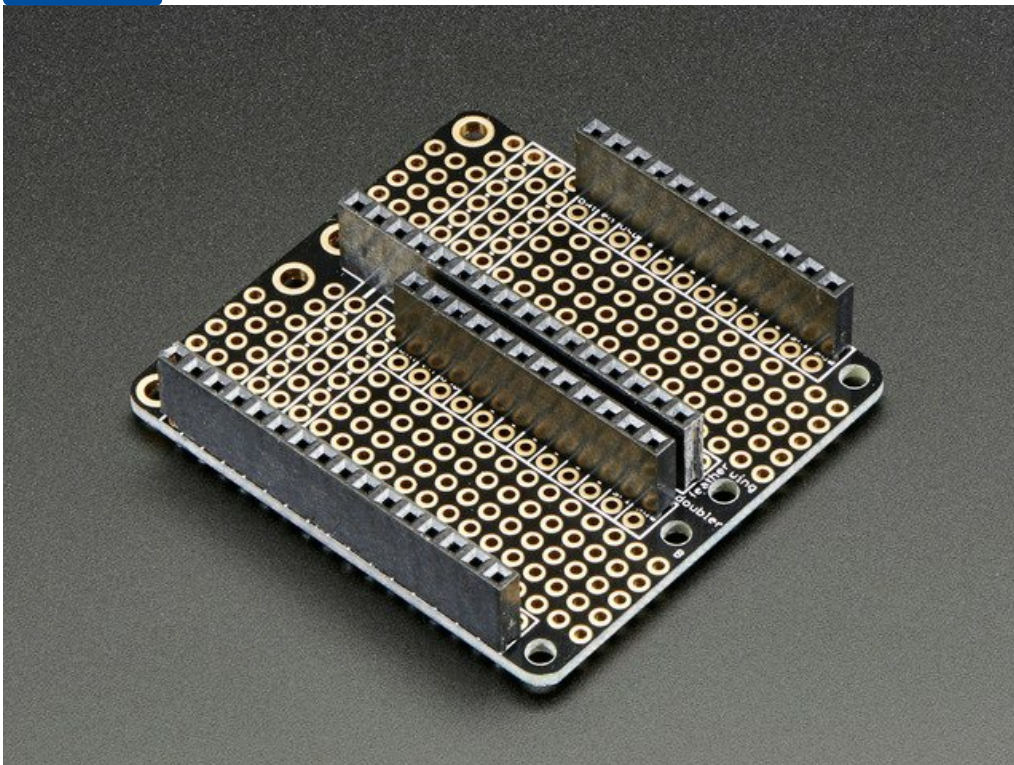
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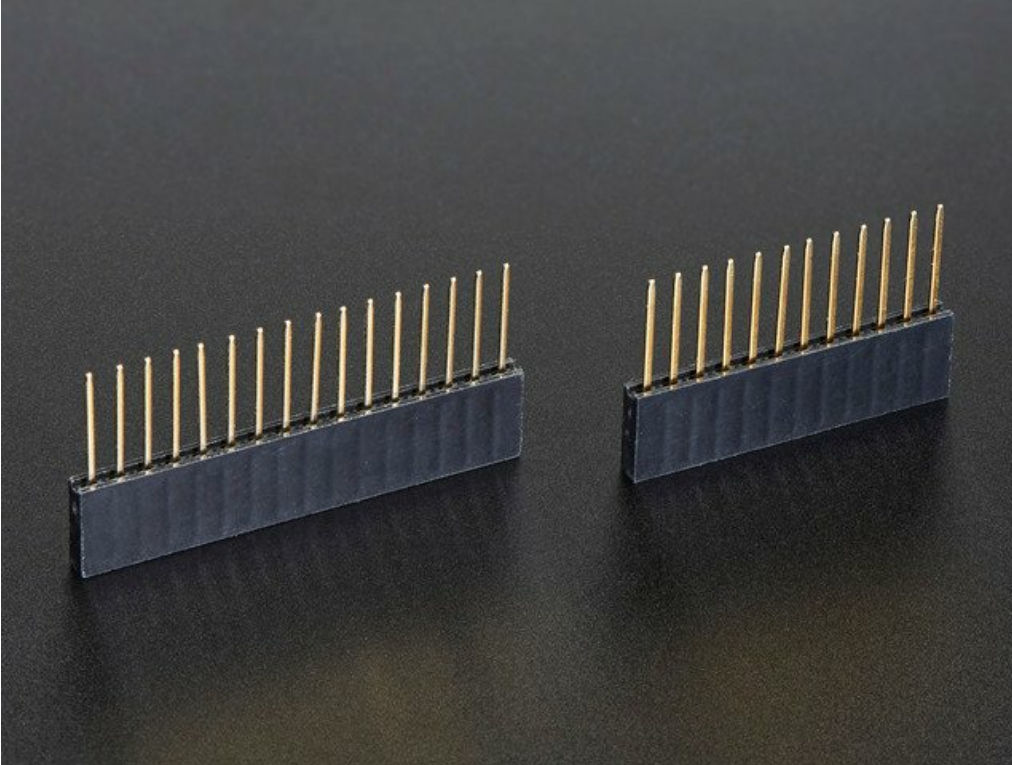
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□

Using sdioio

sdioio uses SDIO high-speed interface to communicate with SD cards, it is not pin compatible with SPI and requires special wiring. Not all chips support SDIO, and if they do, you usually have to use special pins! It also requires CircuitPython 6.0.

Use the code and wiring examples in this section if these conditions are met:

- Your SD card slot uses the SDIO bus to connect to a 3V microcontroller (If it uses SPI, go to [the page for sdcardio](#) (<https://adafru.it/MA6>))
- Your CircuitPython board supports the `sdioio` module. (If not, you may be able to use `bitbangio` and `adafruit_sdcard`)

The following section will show how to initialize the SD card and read & write data to it. You'll want to put the correct lines to initialize it in `mount_sd.py` on your `CIRCUITPY` drive. For specific wiring information and exact `mount_sd.py` files for several different boards, check out the following pages.

Initialize & Mount SD Card Filesystem

Before you can use the microSD card you need to initialize its SDIO connection and mount its filesystem. First import all the modules we'll need:

```
import board
import sdioio
import storage
```

At this point you're ready to create the microSD card object and the filesystem object:

```
sdcard = sdioio.SDCard(
    clock=board.SDIO_CLOCK,
    command=board.SDIO_COMMAND,
    data=board.SDIO_DATA,
    frequency=25000000)

vfs = storage.VfsFat(sdcard)
```

Notice the `sdioio` module has a `SDCard` class which contains all the logic for talking to the microSD card at a low level. This class needs to be told the pins to use in its constructor. `SDIO_DATA` is actually a tuple of up to 4 data pins.

After a `SDCard` instance is created, it can be passed to the `storage` module `VfsFat` class. This class has all the logic for translating CircuitPython filesystem calls into low level microSD card access. Both the `SDCard` and `VfsFat` class instances are required to mount the card as a new filesystem.

Finally you can mount the microSD card filesystem into the CircuitPython filesystem. For example to make the path `/sd` on the CircuitPython filesystem read and write from the card run this command:

```
storage.mount(vfs, "/sd")
```

At this point, you can read and write to the SD card using common Python functions like `open`, `read`, and

`write`. The filenames will all begin with `"/sd/"` to differentiate them from the files on the **CIRCUITPY** drive. If you're not familiar, here's an overview.

Reading & Writing Data

Once the microSD card is mounted inside CircuitPython's filesystem you're ready to read and write data from it. Reading and writing data is simple using Python's file operations like `open` (<https://adafru.it/reL>), `close` (<https://adafru.it/ryE>), `read` (<https://adafru.it/ryE>), and `write` (<https://adafru.it/ryE>). The beauty of CircuitPython and MicroPython is that they try to be as similar to desktop Python as possible, including access to files.

For example to create a file and write a line of text to it you can run:

```
with open("/sd/test.txt", "w") as f:
    f.write("Hello world!\r\n")
```

Notice the `with` statement is used to create a context manager that opens and automatically closes the file. This is handy because with file access you Python you **must** close the file when you're done or else all the data you thought was written might be lost!

The `open` function is used to open the file by telling it the path to it, and the mode (w for writing). Notice the path is under `/sd`, `/sd/test.txt`. This means the file will be created on the microSD card that was mounted as that path.

Inside the context manager you can access the `f` variable to operate on the file while it's open. The `write` function is called to write a line of text to the file. Notice that unlike a `print` statement you need to end the string passed to write with explicit carriage returns and new lines.

You can also open a file and read a line from it with similar code:

```
with open("/sd/test.txt", "r") as f:
    print("Read line from file:")
    print(f.readline(), end='')
```

When reading a line from a file with `readline`, the newline character `\n` at the end of the line is included. By printing with `end=""`, the newline normally added by `print` is skipped. Otherwise, when reading back the file, it would appear that there were extra blank lines after every line of the file.

If you wanted to read and print all of the lines from a file you could call `readline` in a loop. Once `readline` reaches the end of the file it will return an empty string so you know when to stop:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    line = f.readline()
    while line != '':
        print(line, end='')
        line = f.readline()
```

You can also just use the open file object in a `for` loop. Each time the loop runs, the loop variable will be assigned the content of the next line of the file:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    for line in file:
        print(line, end='')
```

Finally one other very common file scenario is opening a file to add new data at the end, or append data. This works exactly the same as in Python and the `open` function can be told you'd like to append instead of erase and write new data (what normally happens with the `w` option for `open`). For example to add a line to the file:

```
with open("/sd/test.txt", "a") as f:
    f.write("This is another line!\r\n")
```

Notice the `a` option in the open function--this tells Python to add data at the end of the file instead of erasing it and starting over at the top. Try reading the file with the code above to see the new line that was added!

Those are the basics to manipulating files on microSD cards with CircuitPython! Once you have it working, put the correct lines in `mount_sd.py` in `CIRCUITPY`, then continue learning by checking out the example pages to print directory listings, log sensor data, play MP3 files and display bitmap graphics.

Example complete `mount_sd.py`

This example is for Grand Central M4 Express with the "SPI or SDIO Breakout", using the SDIO connection:

```
import board
import sdioio
import storage

sdcard = sdioio.SDCard(
    clock=board.SDIO_CLOCK,
    command=board.SDIO_COMMAND,
    data=board.SDIO_DATA,
    frequency=25000000)

vfs = storage.VfsFat(sdcard)

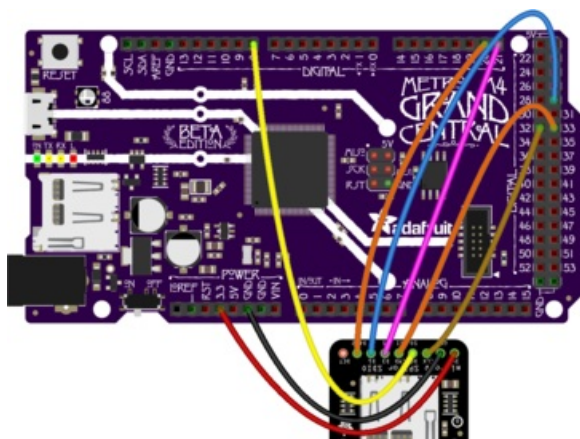
storage.mount(vfs, "/sd")
```

Your board may be different. Refer to the following pages for more details.

Grand Central M4 Express + SDIO Breakout

sdioio uses SDIO high-speed interface to communicate with SD cards, it is not pin compatible with SPI and requires special wiring. Not all chips support SDIO, and if they do, you usually have to use special pins! It also requires CircuitPython 6.0.

The Adafruit Grand Central M4 Express supports SDIO mode with the SDIO Breakout Board. First, wire the two together as shown:



- Board 3.3 to breakout 3V
- Board GND to breakout GND
- Board D32 to breakout CLK
- Board D33 to breakout CMD
- Board D8 to breakout D0
- Board D29 to breakout D1
- Board D20 to breakout DAT2
- Board D21 to breakout D3

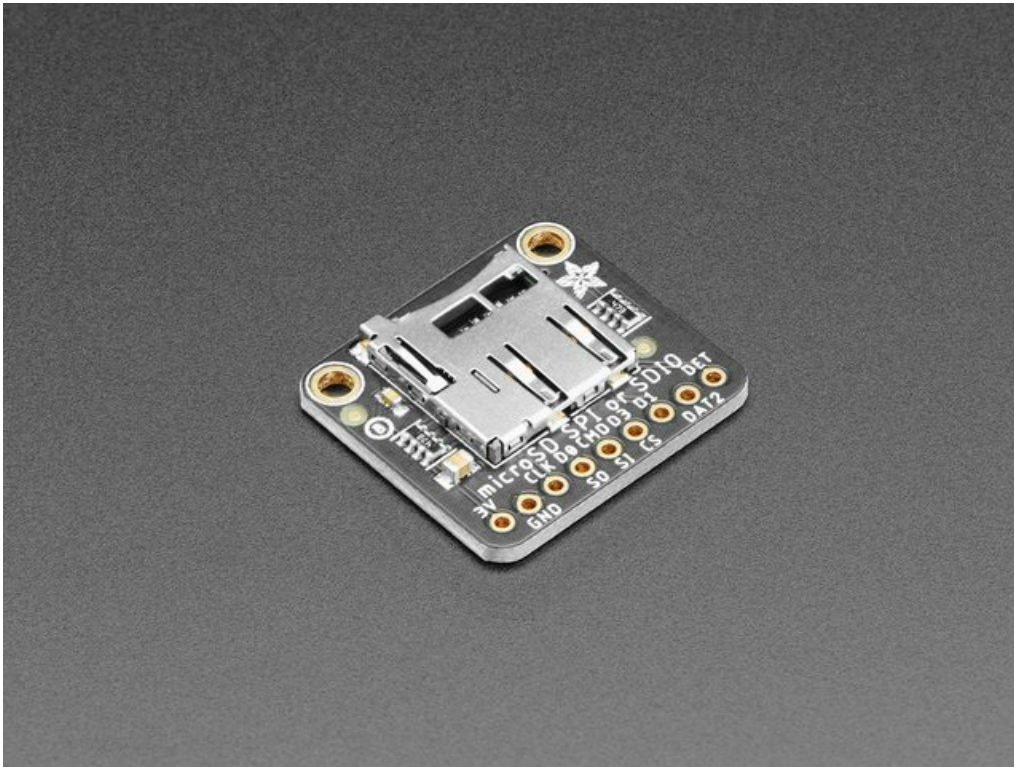
To mount the SD card, use the following code. Remember to put it in the file `mount_sd.py` on **CIRCUITPY** so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import board
import sdioio
import storage

sdcard = sdioio.SDCard(
    clock=board.SDIO_CLOCK,
    command=board.SDIO_COMMAND,
    data=board.SDIO_DATA,
    frequency=25000000)

vfs = storage.VfsFat(sdcard)

storage.mount(vfs, "/sd")
```



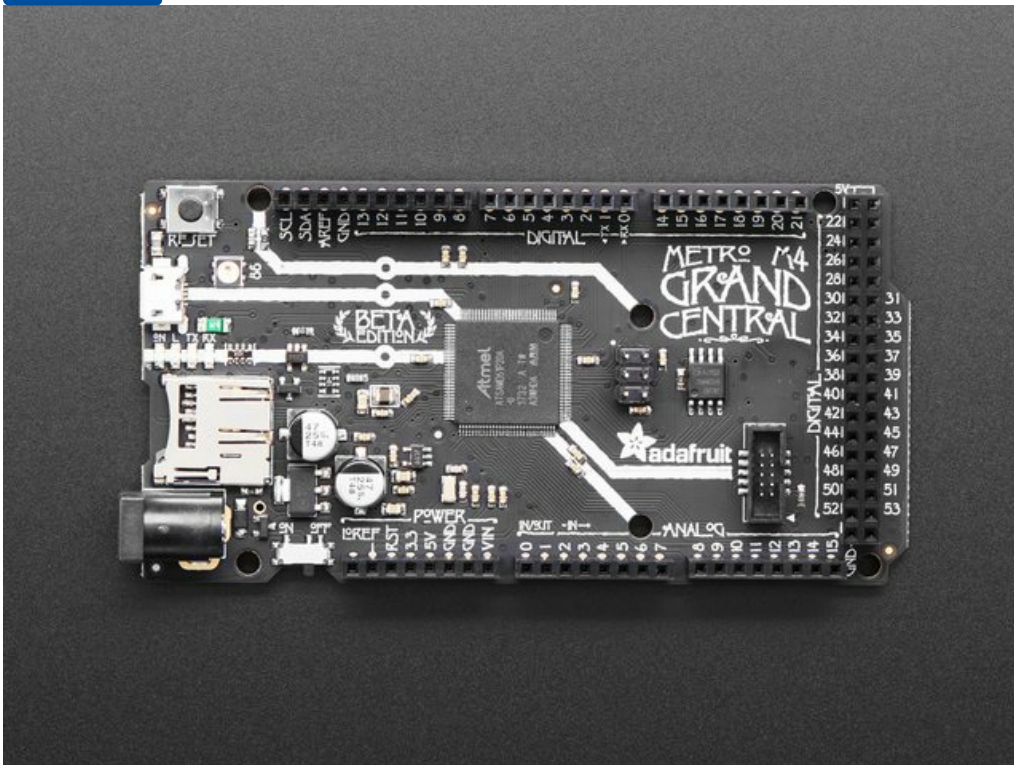
Adafruit Micro SD SPI or SDIO Card Breakout Board - 3V ONLY!

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Feather STM32F405 Express

sdioio uses SDIO high-speed interface to communicate with SD cards, it is not pin compatible with SPI and requires special wiring. Not all chips support SDIO, and if they do, you usually have to use special pins! It also requires CircuitPython 6.0.



The Feather STM32F405 Express uses SDIO to connect its built in micro SD card slot. Didn't notice it had an SD card slot? We hid it on the underside.

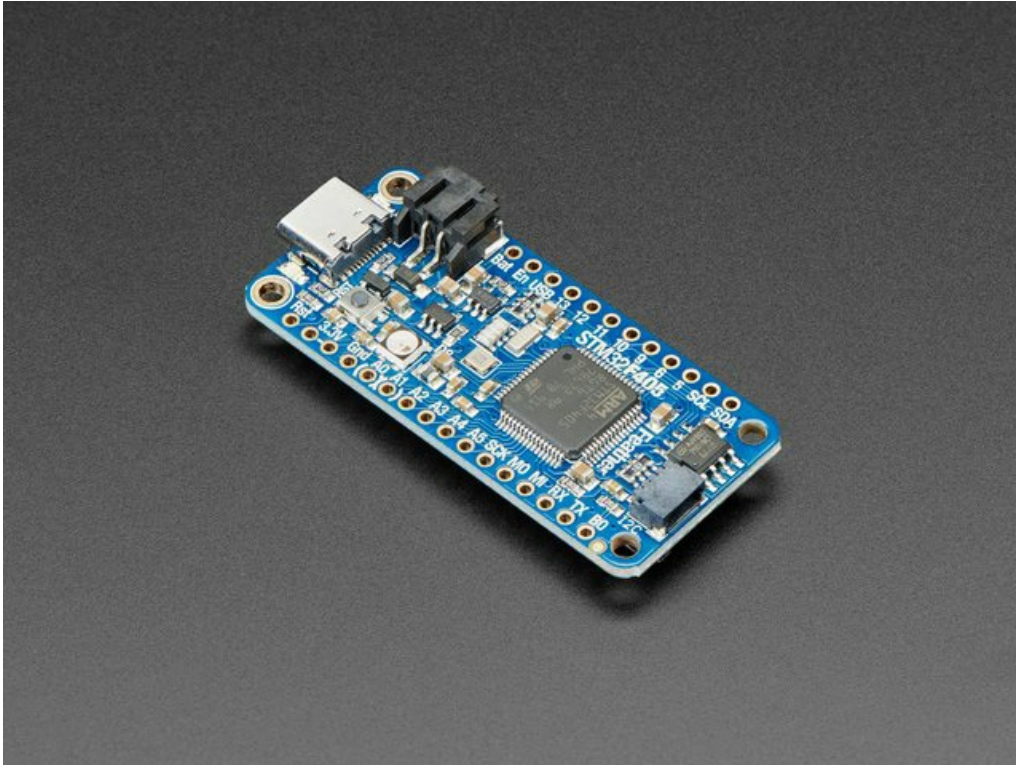
To mount the SD card, use the following code. Remember to put it in the file `mount_sd.py` on CIRCUITPY so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import board
import sdioio
import storage

sdcard = sdioio.SDCard(
    clock=board.SDIO_CLOCK,
    command=board.SDIO_COMMAND,
    data=board.SDIO_DATA,
    frequency=25000000)

vfs = storage.VfsFat(sdcard)

storage.mount(vfs, "/sd")
```



[Adafruit Feather STM32F405 Express](#)

ST takes flight in this Feather board. The new STM32F405 Feather (video) that we designed runs CircuitPython at a blistering 168MHz –...

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Python Docs

Python Docs (<https://adafru.it/Mmd>)



Adafruit CircuitPython SD

The original `adafruit_sd` library is available for older M0 boards that don't have enough flash for the new updated `sdcardio` optimized library. It's slower, but works well enough for basic SD card usages!

Use the code and wiring examples in this section if:

- Your board doesn't support `sdcardio` or `sdioio`

This is the case particularly for older and lower-capacity microcontroller like the M0 series.

The following section will show how to initialize the SD card and read & write data to it. You'll want to put the correct lines to initialize it in `mount_sd.py` on your **CIRCUITPY** drive. For typical wiring information and exact `mount_sd.py` files for several different boards, check out next page.

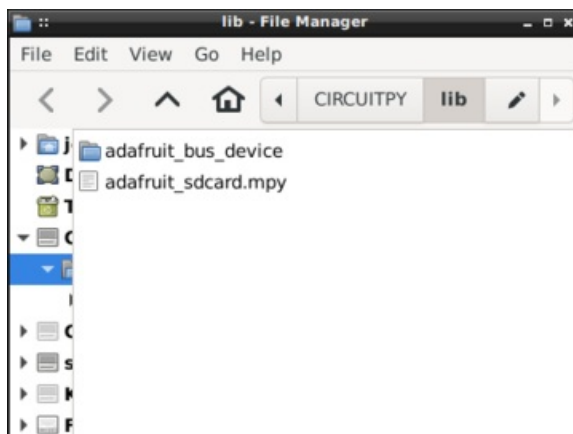
Adafruit CircuitPython Module Install

You'll need to install the [Adafruit CircuitPython SD \(https://adafru.it/zwC\)](https://adafru.it/zwC) library on your CircuitPython board.

First make sure you are running the [latest version of Adafruit CircuitPython \(https://adafru.it/Amd\)](https://adafru.it/Amd) for your board.

Next you'll need to install the necessary libraries to use the hardware--carefully follow the steps to find and install these libraries from [Adafruit's CircuitPython library bundle \(https://adafru.it/ENC\)](https://adafru.it/ENC).

Our CircuitPython starter guide has [a great page on how to install libraries from the bundle \(https://adafru.it/ABU\)](https://adafru.it/ABU).



Load the the following libraries into the `lib` folder on your **CIRCUITPY** drive:

- `adafruit_sdcard.mpy`
- `adafruit_bus_device`

Before continuing make sure your board's `lib` folder or root filesystem has the `adafruit_sdcard.mpy` file and `adafruit_bus_device` folder copied over.

Initialize & Mount SD Card Filesystem

Before you can use the microSD card you need to initialize its SPI connection and mount its filesystem.

First import all the modules we'll need:

```
import adafruit_sdcard
import board
import busio
import digitalio
import storage
```


Next create the SPI bus and a digital output for the microSD card's chip select line (be sure to select the right pin names for your wiring):

```
# Use the board's primary SPI bus
spi = board.SPI()
# Or, use an SPI bus on specific pins:
#spi = busio.SPI(board.SD_SCK, MOSI=board.SD_MOSI, MISO=board.SD_MISO)

# Boards with built in SPI SD card slots will generally have a
# pin called SD_CS:
cs = digitalio.DigitalInOut(board.SD_CS)
# For breakout boards, you can choose any GPIO pin that's convenient:
#cs = digitalio.DigitalInOut(board.D10)
```

Note that when you use `adafruit_sdcard`, `cs` is a `DigitalInOut` object, not a `microcontroller.Pin` object. If you change your code to use `sdcardio`, you need to use a `Pin` object instead.

At this point you're ready to create the microSD card object and the filesystem object:

```
sdcard = adafruit_sdcard.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
```

Notice the `sdcardio` module has a `SDCard` class which contains all the logic for talking to the microSD card at a low level. This class needs to be told the SPI bus and chip select pin in its constructor.

After a `SDCard` instance is created it can be passed to the `storage` module's `VfsFat` class. This class has all the logic for translating CircuitPython filesystem calls into low level microSD card access. Both the `SDCard` and `VfsFat` class instances are required to mount the card as a new filesystem.

Finally you can mount the microSD card's filesystem into the CircuitPython filesystem. For example to make the path `/sd` on the CircuitPython filesystem read and write from the card run this command:

```
storage.mount(vfs, "/sd")
```

At this point, you can read and write to the SD card using common Python functions like `open`, `read`, and `write`. The filenames will all begin with `"/sd/"` to differentiate them from the files on the `CIRCUITPY` drive. If you're not familiar, here's an overview.

Reading & Writing Data

Once the microSD card is mounted inside CircuitPython's filesystem you're ready to read and write data from it. Reading and writing data is simple using Python's file operations like `open` (<https://adafru.it/reL>), `close` (<https://adafru.it/ryE>), `read` (<https://adafru.it/ryE>), and `write` (<https://adafru.it/ryE>). The beauty of CircuitPython and MicroPython is that they try to be as similar to desktop Python as possible, including access to files.

For example to create a file and write a line of text to it you can run:

```
with open("/sd/test.txt", "w") as f:
    f.write("Hello world!\r\n")
```

Notice the `with` statement is used to create a context manager that opens and automatically closes the file. This is handy because with file access you Python you **must** close the file when you're done or else all

the data you thought was written might be lost!

The `open` function is used to open the file by telling it the path to it, and the mode (w for writing). Notice the path is under `/sd`, `/sd/test.txt`. This means the file will be created on the microSD card that was mounted as that path.

Inside the context manager you can access the `f` variable to operate on the file while it's open. The `write` function is called to write a line of text to the file. Notice that unlike a `print` statement you need to end the string passed to write with explicit carriage returns and new lines.

You can also open a file and read a line from it with similar code:

```
with open("/sd/test.txt", "r") as f:
    print("Read line from file:")
    print(f.readline(), end='')
```

When reading a line from a file with `readline`, the newline character `\n` at the end of the line is included. By printing with `end=""`, the newline normally added by print is skipped. Otherwise, when reading back the file, it would appear that there were extra blank lines after every line of the file.

If you wanted to read and print all of the lines from a file you could call `readline` in a loop. Once `readline` reaches the end of the file it will return an empty string so you know when to stop:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    line = f.readline()
    while line != '':
        print(line, end='')
        line = f.readline()
```

You can also just use the open file object in a `for` loop. Each time the loop runs, the loop variable will be assigned the content of the next line of the file:

```
with open("/sd/test.txt", "r") as f:
    print("Printing lines in file:")
    for line in file:
        print(line, end='')
```

Finally one other very common file scenario is opening a file to add new data at the end, or append data. This works exactly the same as in Python and the `open` function can be told you'd like to append instead of erase and write new data (what normally happens with the `w` option for `open`). For example to add a line to the file:

```
with open("/sd/test.txt", "a") as f:
    f.write("This is another line!\r\n")
```

Notice the `a` option in the open function--this tells Python to add data at the end of the file instead of erasing it and starting over at the top. Try reading the file with the code above to see the new line that was added!

Those are the basics to manipulating files on microSD cards with CircuitPython! Once you have it

working, put the correct lines in `mount_sd.py` in **CIRCUITPY**, then continue learning by checking out the example pages to print directory listings, log sensor data, play MP3 files and display bitmap graphics.

Example complete `mount_sd.py`

This example works on the AdaLogger M0:

```
import adafruit_sdcard
import board
import busio
import digitalio
import storage

spi = board.SPI()
cs = digitalio.DigitalInOut(board.SD_CS)

sdcard = adafruit_sdcard.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```

Your board may be different. Refer to the following pages for more details.

Adalogger M0 Feather

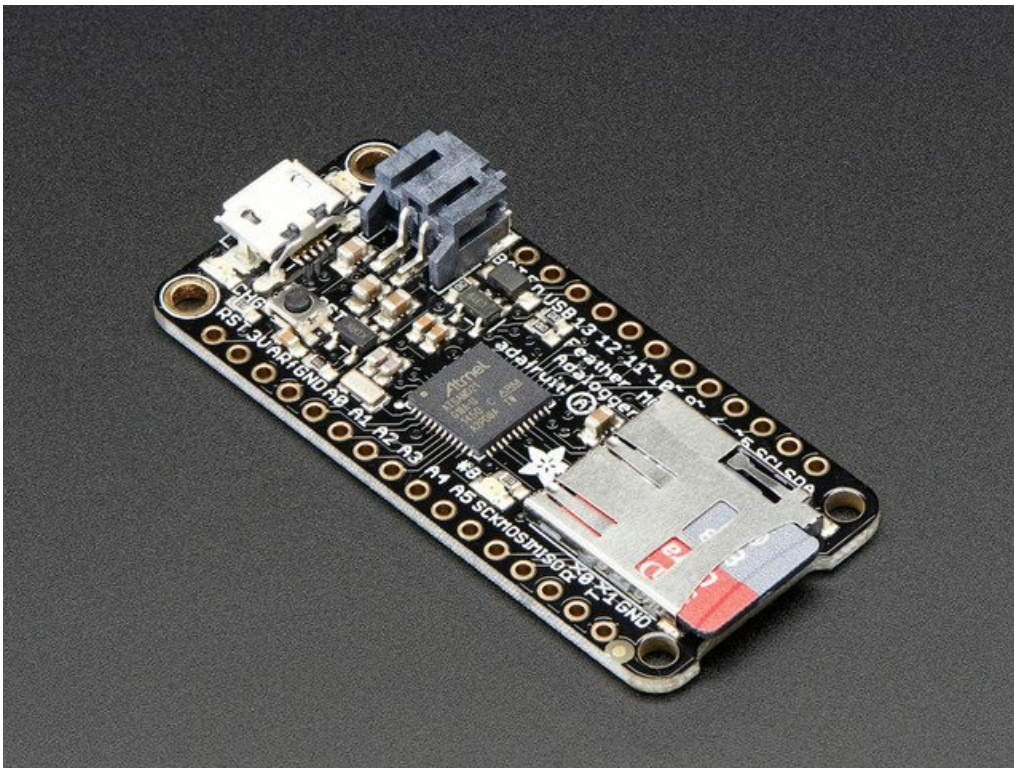
The Feather M0 Adalogger is a classic board that doesn't have the same power as its newer siblings, but it's still good for logging. Best of all, no soldering is necessary to access the SD card.

To mount the SD card, use the following code. Remember, to put it in the file `mount_sd.py` on **CIRCUITPY** so you can easily call it from `code.py` or the REPL with `import mount_sd`.

```
import adafruit_sdcard
import board
import busio
import digitalio
import storage

spi = board.SPI()
cs = digitalio.DigitalInOut(board.SD_CS)

sdcard = adafruit_sdcard.SDCard(spi, cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, "/sd")
```



[Adafruit Feather M0 Adalogger](#)

Feather is the new development board from Adafruit, and like its namesake it is thin, light, and lets you fly! We designed Feather to be a new standard for portable microcontroller...

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Python Docs

[Python Docs \(https://adafru.it/C5z\)](https://adafru.it/C5z)

Examples

The following examples assume sure you've [configured mount_sd.py](https://adafru.it/MA7) for your board. If you can `import mount_sd` at the REPL without getting an error, you should be good to go.

```
>>> import mount_sd
>>>
```

Listing files on SD card

Put the code below in `code.py` on your **CIRCUITPY** drive, open up the REPL (and restart it with ^D if necessary) to get a listing of all the files an SD card contains. We recursively print out all files and also the filesize. This is a good demo to start with because you can at least tell if your files exist!

This example will work on any board where you've [configured `mount_sd.py`](https://adafru.it/MA7)!

The function `print_directory` works using `os.listdir` (to list files in a directory) and `os.stat` (to get information about an item, such as size or whether it's a directory).

By keeping track of the nesting of directories within directories, names are indented according to the value of `tabs` to show the directory structure.

```
import os

import mount_sd

def print_directory(path, tabs=0):
    for file in os.listdir(path):
        stats = os.stat(path + "/" + file)
        filesize = stats[6]
        isdir = stats[0] & 0x4000

        if filesize < 1000:
            sizestr = str(filesize) + " by"
        elif filesize < 1000000:
            sizestr = "%0.1f KB" % (filesize / 1000)
        else:
            sizestr = "%0.1f MB" % (filesize / 1000000)

        prettyprintname = ""
        for _ in range(tabs):
            prettyprintname += "  "
        prettyprintname += file
        if isdir:
            prettyprintname += "/"
        print('{0:<40} Size: {1:>10}'.format(prettyprintname, sizestr))

        # recursively print directory contents
        if isdir:
            print_directory(path + "/" + file, tabs + 1)

print("Files on filesystem:")
print("=====")
print_directory("/sd")
```


Benchmarking SD card access

Put the code below in `code.py` on your **CIRCUITPY** drive, open up the REPL (and restart it with ^D if necessary) to get report of how quickly CircuitPython can read and write your SD card.

This example will work on any board where you've [configured `mount_sd.py`](https://adafru.it/MA7)!

We saw some great speed increases going from good (`adafruit_sdcard`) to better (`sdcardio`) to best (`sdio`). However, every SD card is different and (especially when writing data) slow down as they "age", so your mileage may vary:

- SD card access with `adafruit_sdcard` on Grand Central:
 - Reads up to 120kB/s
 - Data logging at up to 160 of lines per second
- SD card access with `sdcardio` on Grand Central:
 - Reads up to 650kB/s
 - Data logging at up to 700 of lines per second
- SD card access with `sdioio` on Grand Central with SDIO breakout:
 - Reads up to 1100kB/s
 - Data logging at over 1000 lines per second

```

import time
import os

import mount_sd

# First, just write the file 'hello.txt' to the card
with open("/sd/hello.txt", "w") as f: print("hello world", file=f)

print()
print("SD card I/O benchmarks")

# Test read and write speed in several scenarios:
# * 512 or 4096 bytes at a time
# * Writing 1 time or 16 times
# First write the content to the SD card, then read it back, reporting the
# time taken.
for sz in 512, 4096:
    b = bytearray(sz)
    for i in range(sz): b[i] = 0xaa
    for n in (1, 16):
        with open("/sd/hello.bin", "wb") as f:
            t0 = time.monotonic_ns()
            for i in range(n):
                f.write(b)
            t1 = time.monotonic_ns()

        dt = (t1-t0) / 1e9
        print(f"write {len(b)} x {n} in {dt}s {n * len(b) / dt / 1000:.1f}Kb/s")

        with open("/sd/hello.bin", "rb") as f:
            t0 = time.monotonic_ns()
            for i in range(n):
                f.readinto(b)
            t1 = time.monotonic_ns()

        dt = (t1-t0) / 1e9

        print(f"read {len(b)} x {n} in {dt}s {n * len(b) / dt / 1000:.1f}Kb/s")
    print()

# Test "logging" speed and report the time to write each line.
# Note that in this test the file is not closed or flushed after each
# line, so in the event of power loss some lines would be lost. However,
# it allows much more frequent logging overall.
#
# If keeping data integrity is your highest concern, follow the logging
# example, not this logging benchmark!
print("logging test")
with open("/sd/log.txt", "wt") as logfile:
    t0 = time.monotonic_ns()
    for i in range(10000):
        t1 = time.monotonic_ns()
        dt = (t1-t0) / 1e9
        print(f"Line {i}, {dt:2f}s elapsed", file=logfile)
t1 = time.monotonic_ns()
dt = (t1-t0) / 1e9

print(f"Logged 10000 lines in {dt} seconds, {dt*100:.0f}us/line")
sz = os.stat('/sd/log.txt')[6]
print(f"{sz} bytes written, {sz/dt/1000:.1f}Kb/s")

```


Logging temperature to SD card

Did you know your CircuitPython-compatible microcontroller probably has a thermometer inside? It does! `microcontroller.cpu.temperature` reflects the temperature inside the microcontroller itself, which will frequently be 3-4 degrees C above the ambient temperature. Note that temperatures are reported in Celsius, not Fahrenheit.

This is a great example to extend with the sensor(s) of your choice, as well as with a Real Time Clock (RTC) so that you know the time that each reading was recorded. We chose the internal temperature to make this work with a wide range of boards, as long you've [configured mount_sd.py](https://adafru.it/MA7) (<https://adafru.it/MA7>)!

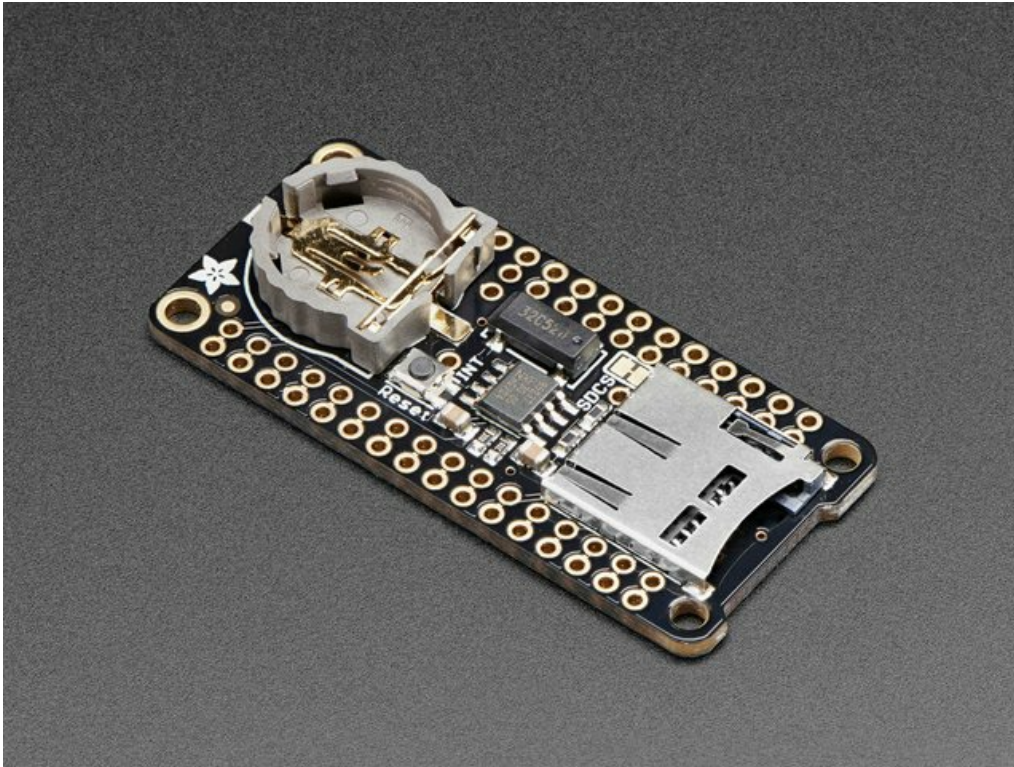
```
import time

import board
import digitalio
import microcontroller
import mount_sd

led = digitalio.DigitalInOut(board.D13)
led.direction = digitalio.Direction.OUTPUT

# Use the filesystem as normal! Our files are under /sd

print("Logging temperature to filesystem")
# append to the file!
while True:
    # open file for append
    with open("/sd/temperature.txt", "a") as f:
        led.value = True # turn on LED to indicate we're writing to the file
        t = microcontroller.cpu.temperature
        print("Temperature = %0.1f" % t)
        f.write("%0.1f\n" % t)
        led.value = False # turn off LED to indicate we're done
    # file is saved
    time.sleep(1)
```



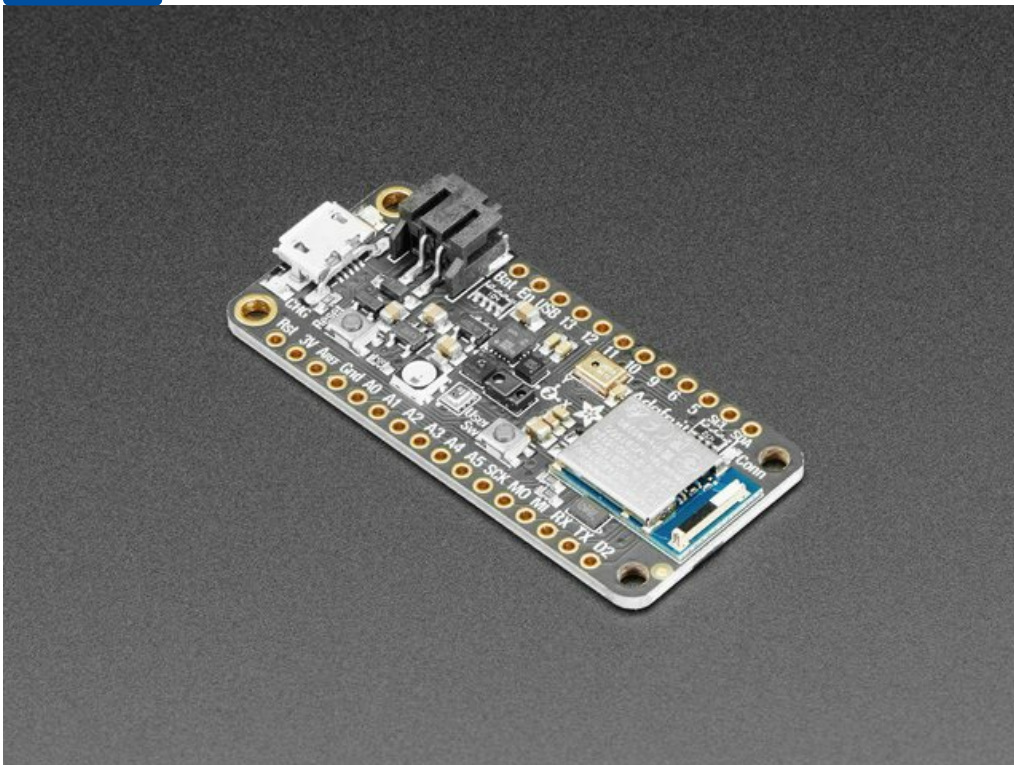
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Playing MP3 from SD Card

This code plays MP3 files without volume control. If you use headphones, choose a set with an in-line volume control and always listen at a safe volume.

Compressed audio can be a nice alternative to uncompressed WAV files - especially when you have a small filesystem like that on many CircuitPython boards: those WAV files get pretty big fast! Thanks to the expiration of the MP3 patent pool, we can now include MP3 decoding as a core CircuitPython capability.

CircuitPython supports any MP3 file you like. We've found that **mono and stereo** files from **32kbit/s** to **128kbit/s** work, with sample rates from **16kHz** to **44.1kHz**. The DAC output on the SAMD51 M4 is just 12-bit so there's not much point in using higher bitrates.

With this example, tailored to the PyGamer, you can loop MP3s to your heart's content (or as long as power lasts). Put the MP3 files in the main folder of your SD card, put the code below in **code.py**, and make sure you've [configured mount_sd.py](https://adafruit.it/MA7)!

This example can be adapted to a lot of SAMD51 and nRF52840 boards. Where there's no headphone jack or speaker connection, consider the Prop Maker Featherwing for your sound-making needs. For more about playing MP3s, visit [the page in the essentials guide](https://adafruit.it/MAS). For a full MP3 player for your PyGamer, see [the dedicated guide](https://adafruit.it/MAt).

```

import os
import time

import board
import digitalio
import mount_sd

# Updating the display can interfere with MP3 playback if it is not
# done carefully
try:
    board.DISPLAY.auto_refresh = False
except:
    pass

from audiomp3 import MP3Decoder

try:
    from audioio import AudioOut
except ImportError:
    try:
        from audiopwmio import PWMAudioOut as AudioOut
    except ImportError:
        pass # not always supported by every board!

# The mp3 files on the sd card will be played in alphabetical order
mp3files = sorted("/sd/" + filename for filename in os.listdir("/sd")
                  if filename.lower().endswith("mp3"))

voodoo = [1,2,3]

# You have to specify some mp3 file when creating the decoder
mp3 = open(mp3files[0], "rb")
decoder = MP3Decoder(mp3)
audio = AudioOut(board.A0, right_channel=board.A1)

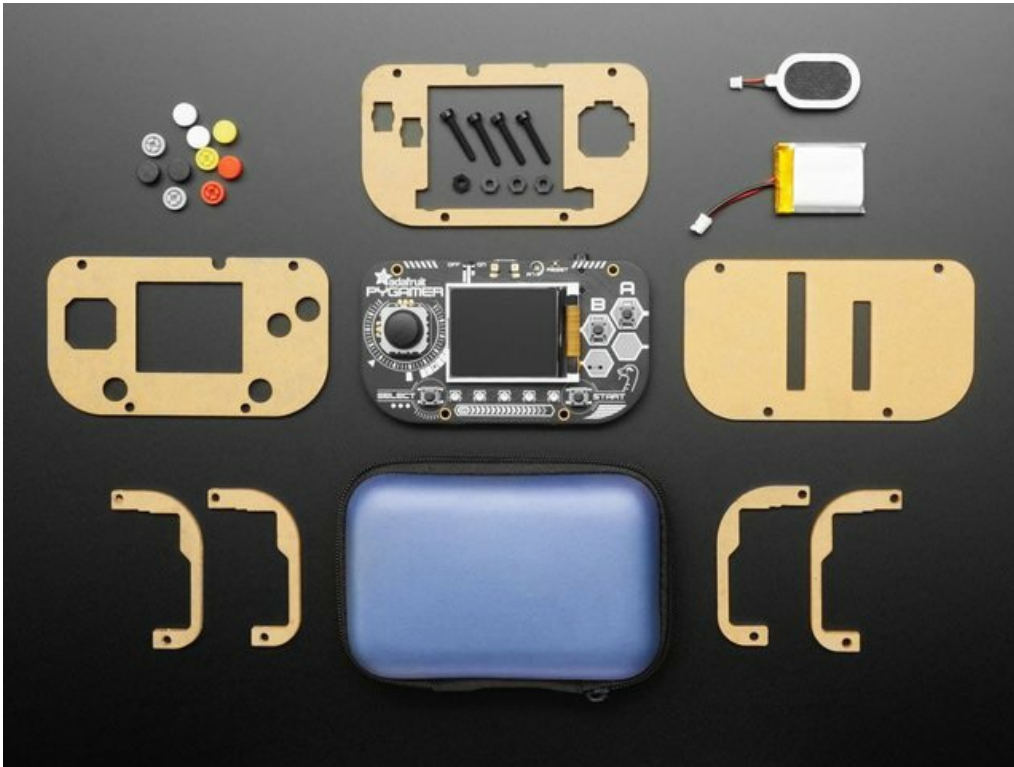
speaker_enable = digitalio.DigitalInOut(board.SPEAKER_ENABLE)
speaker_enable.switch_to_output(True)

while True:
    for filename in mp3files:
        print("Playing", filename)

        # Updating the .file property of the existing decoder
        # helps avoid running out of memory (MemoryError exception)
        decoder.file = open(filename, "rb")
        audio.play(decoder)

        # This allows you to do other things while the audio plays!
        while audio.playing:
            time.sleep(1)

```

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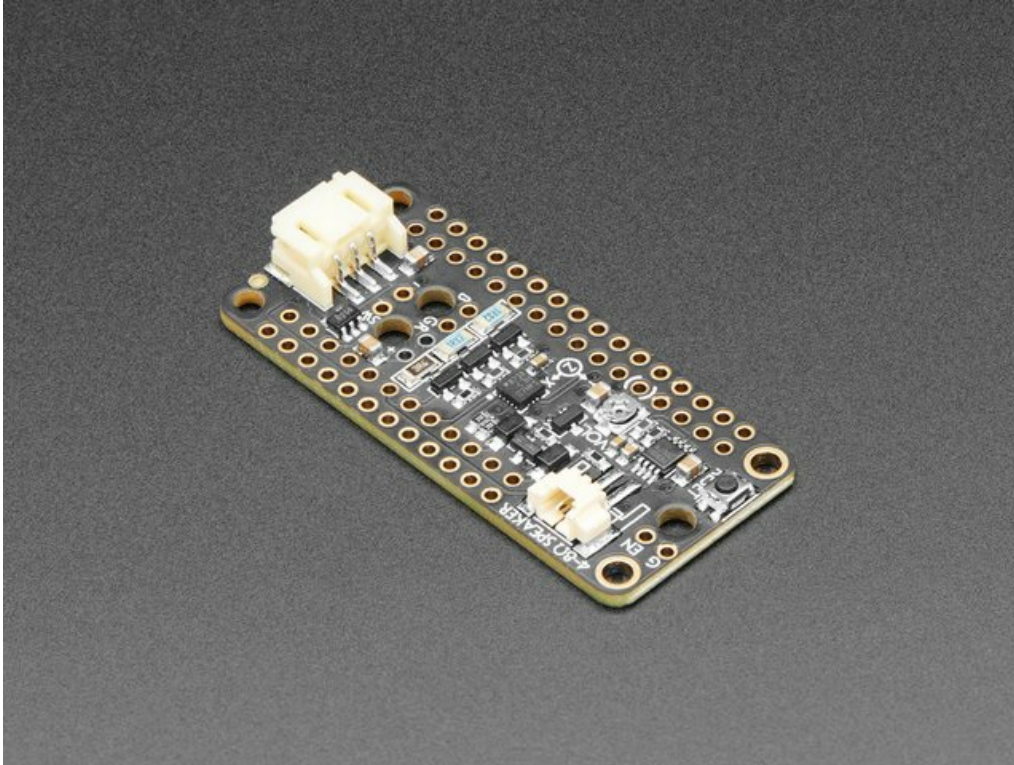


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Showing BMPs from SD card

With this example, tailored to the PyGamer, you can have a portable picture frame. Put the BMP files in the main folder of your SD card, put the code below in `code.py`, and make sure you've [configured mount_sd.py](https://adafru.it/MA7) (<https://adafru.it/MA7>)!

This example can be adapted to a lot of CircuitPython boards with [support for displayio](https://adafru.it/EGh) (<https://adafru.it/EGh>).

For more information on making bitmap files, [check out this guide](https://adafru.it/MbZ) (<https://adafru.it/MbZ>).

```
import os
import time

import board
import digitalio
import displayio
import mount_sd

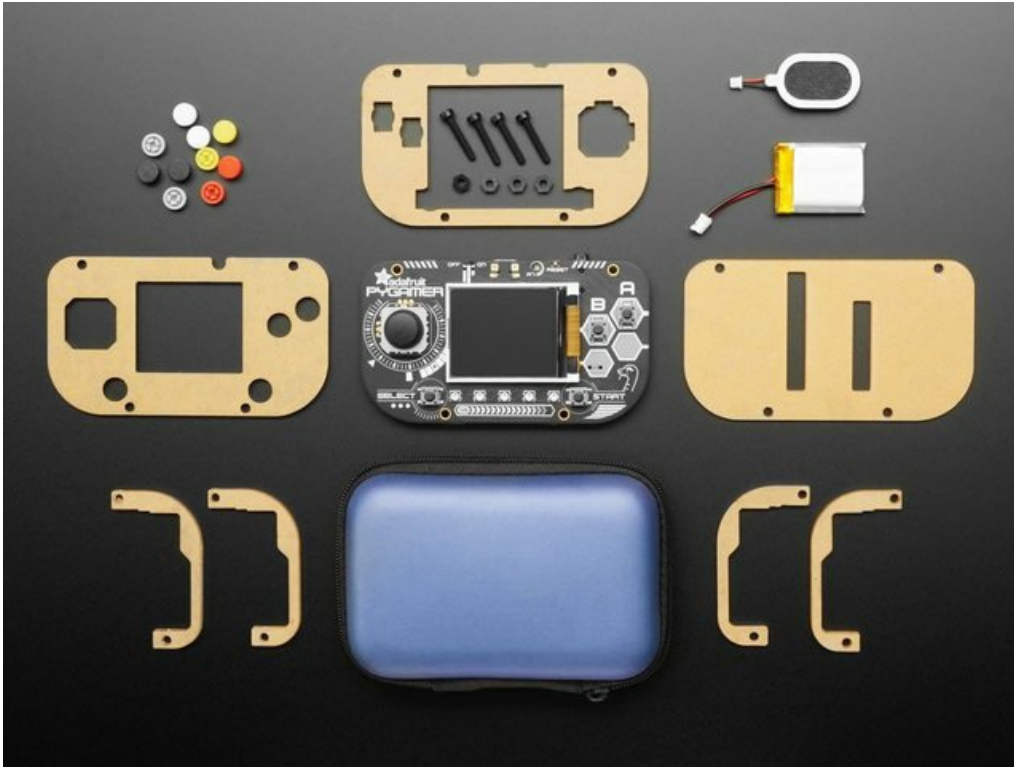
display = board.DISPLAY

# The bmp files on the sd card will be shown in alphabetical order
bmpfiles = sorted("/sd/" + filename for filename in os.listdir("/sd")
                 if filename.lower().endswith("bmp"))

while True:
    for filename in bmpfiles:
        print("showing", filename)

        bitmap_file = open(filename, "rb")
        bitmap = displayio.OnDiskBitmap(bitmap_file)
        tile_grid = displayio.TileGrid(bitmap,
                                       pixel_shader=displayio.ColorConverter())
        group = displayio.Group()
        group.append(tile_grid)
        display.show(group)

        # Show the image for 10 seconds
        time.sleep(10)
```



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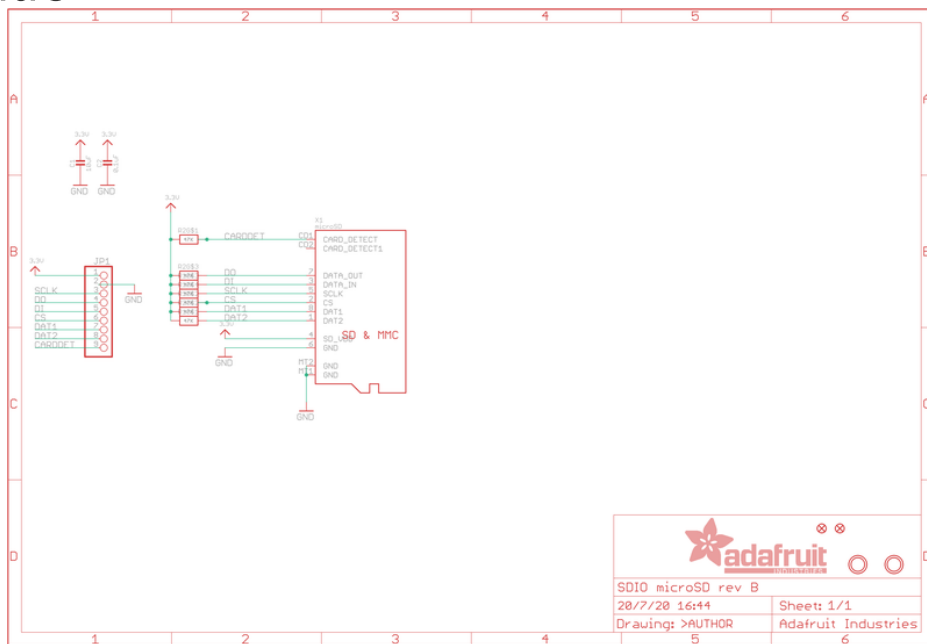
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Downloads

Files

- [SD card simplified specification \(https://adafru.it/MAu\)](https://adafru.it/MAu)
- [EagleCAD files on GitHub \(https://adafru.it/MAv\)](https://adafru.it/MAv)
- [Fritzing object in the Adafruit Fritzing Library \(https://adafru.it/MAw\)](https://adafru.it/MAw)

Schematic



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