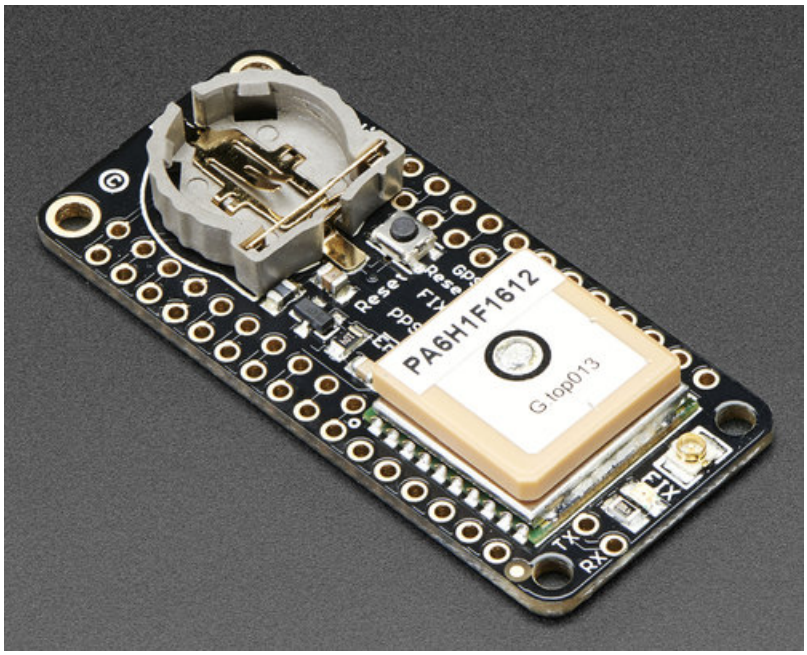
adafruit learning system

Adafruit Ultimate GPS featherwing

Created by lady ada



Last updated on 2017-11-14 11:44:26 PM UTC

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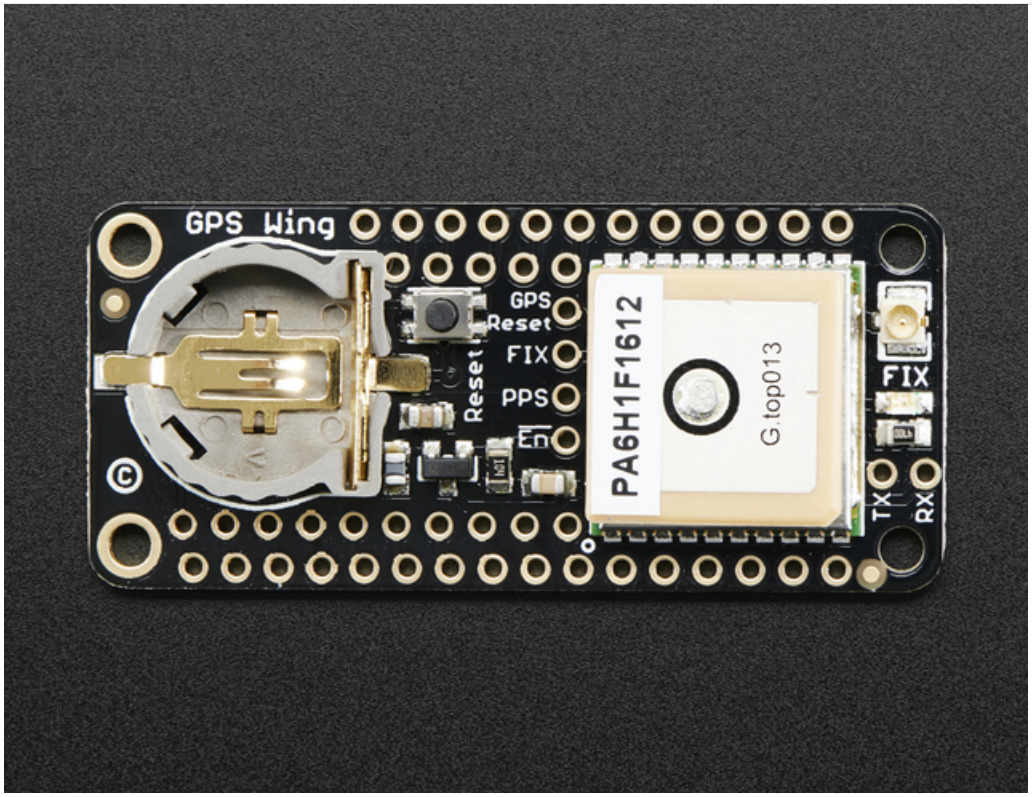
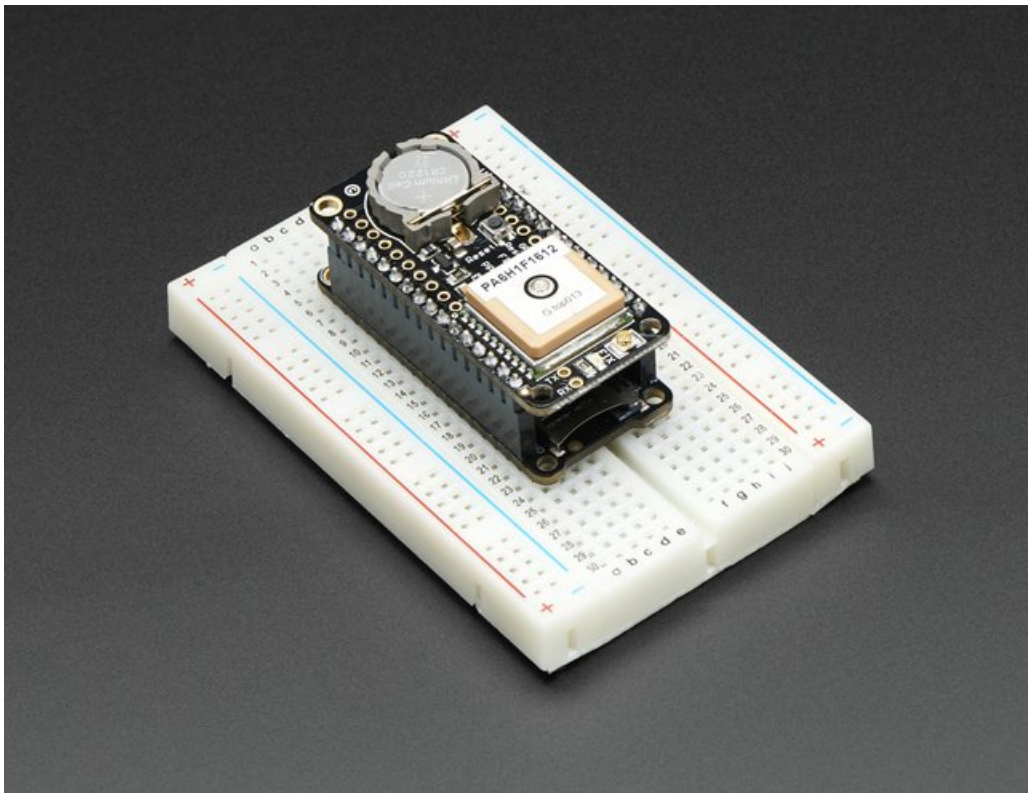
Overview

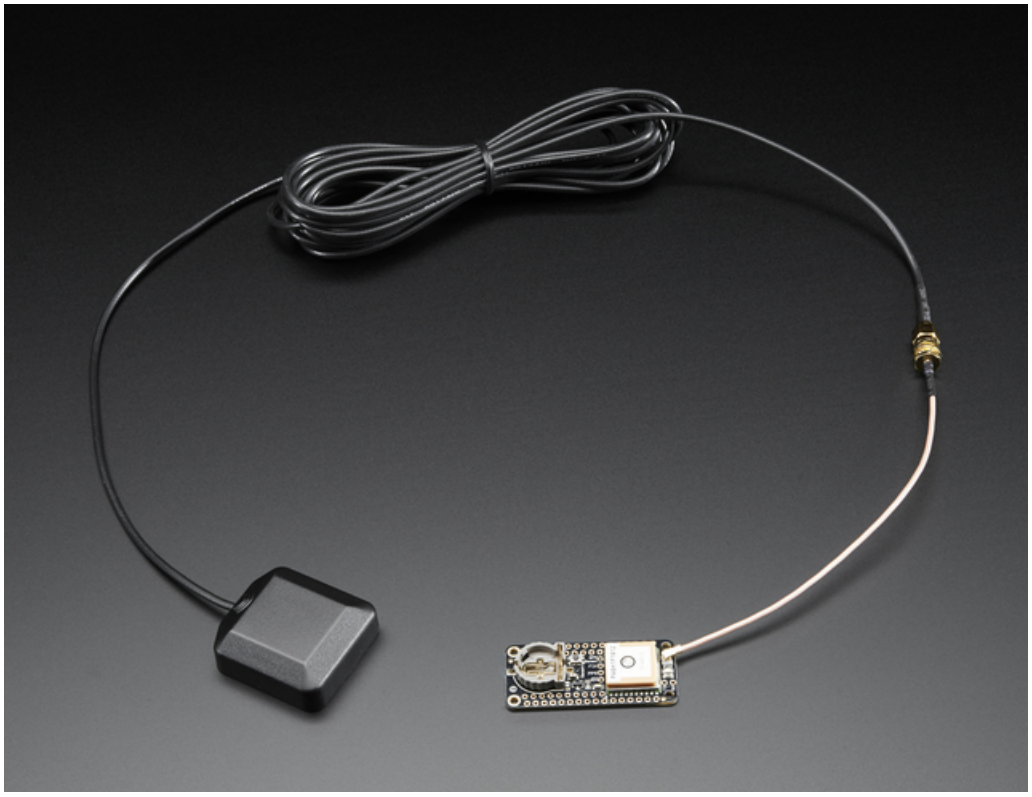


Give your Feather a sense of place, with an Ultimate GPS FeatherWing. This FeatherWing plugs right into your Feather board and gives it a precise, sensitive, and low power GPS module for location identifcation anywhere in the world. As a bonus, the GPS can also keep track of time once it is synced with the satellites.

- -165 dBm sensitivity, 10 Hz updates, 66 channels
- 20mA current draw
- RTC with coin battery backup
- Built-in datalogging
- PPS (pulse per second) output on fix
- Internal patch antenna + u.FL connector for external active antenna
- Fix status LED

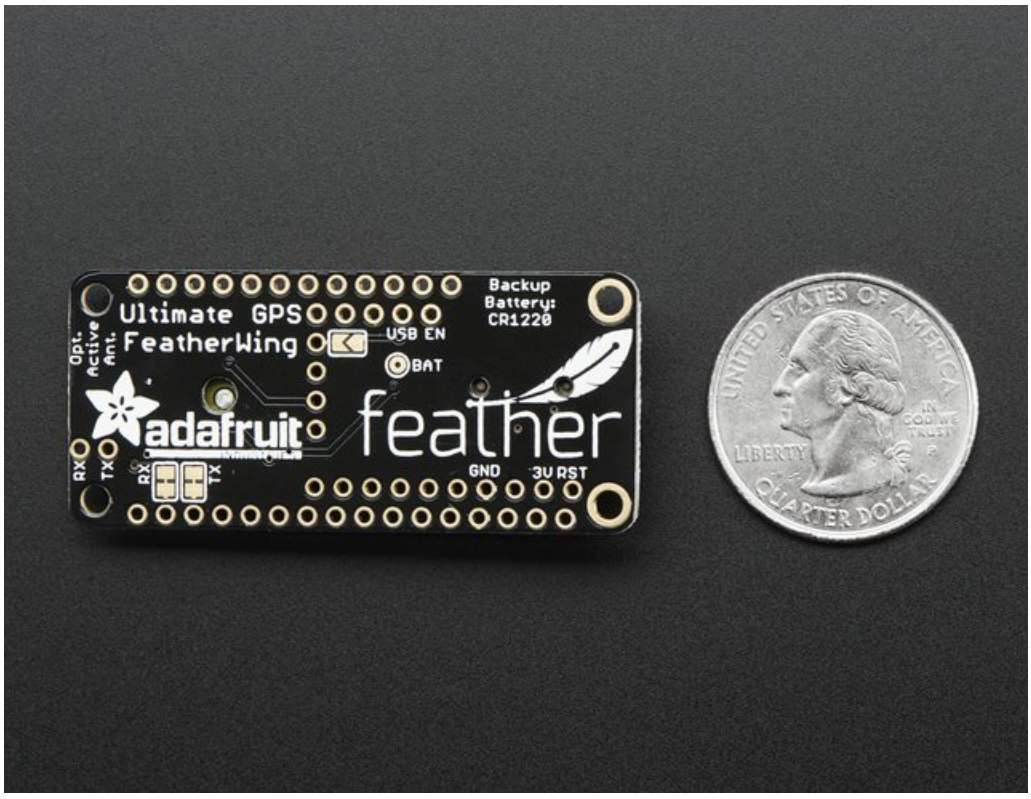


The Wing is built around the MTK3339 chipset, a no-nonsense, high-quality GPS module that can track up to 22 satellites on 66 channels, has an excellent high-sensitivity receiver (-165 dB tracking!), and a built in antenna. It can do up to 10 location updates a second for high speed, high sensitivity logging or tracking. Power usage is incredibly low, only 20 mA during navigation.



The MTK3339-based module has external antenna functionality. The module has a standard ceramic patch antenna that gives it -165 dB sensitivity, but when you want to have a bigger antenna, you can snap on any 3V active GPS antenna via the uFL connector. The module will automatically detect the active antenna and switch over! Most GPS antennas use SMA connectors so you may want to pick up one of our uFL to SMA adapters.

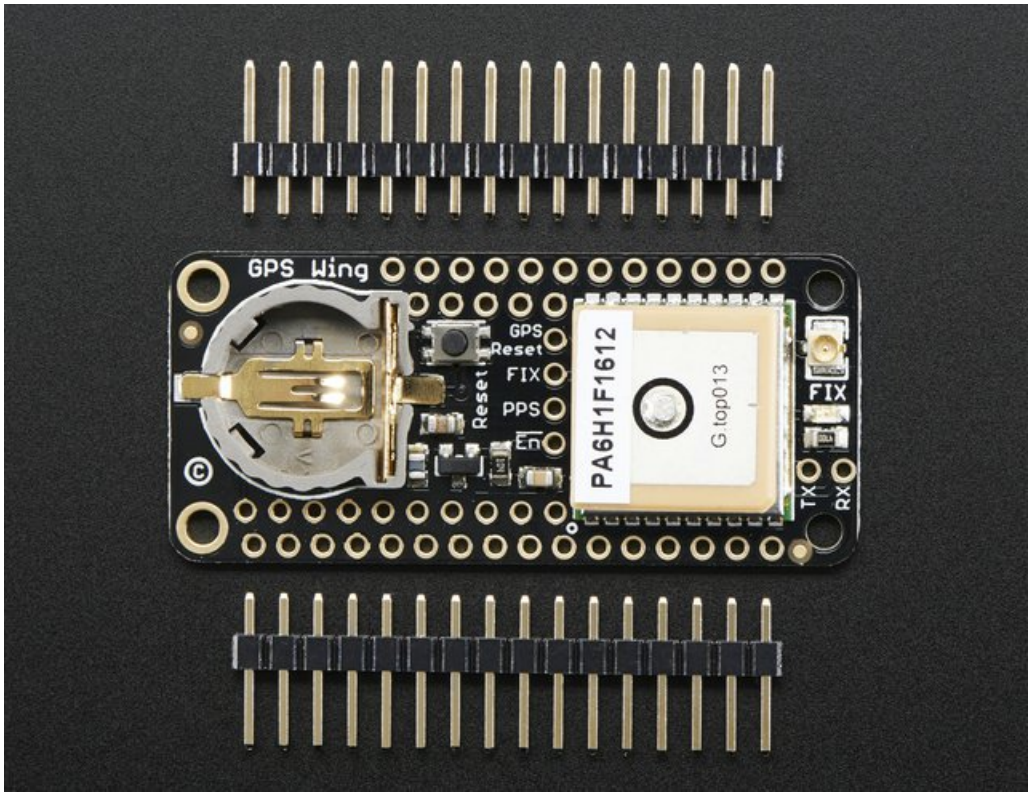
We added some extra goodies to make this GPS FeatherWing better than a breakout: a FET-driven ENABLE pin so you can turn off the module using any microcontroller pin for low power use, a CR1220 coin cell holder to keep the RTC running and allow warm starts and a tiny bright red LED. The LED blinks at about 1Hz while it's searching for satellites and blinks once every 15 seconds when a fix is found to conserve power.



Module specs:

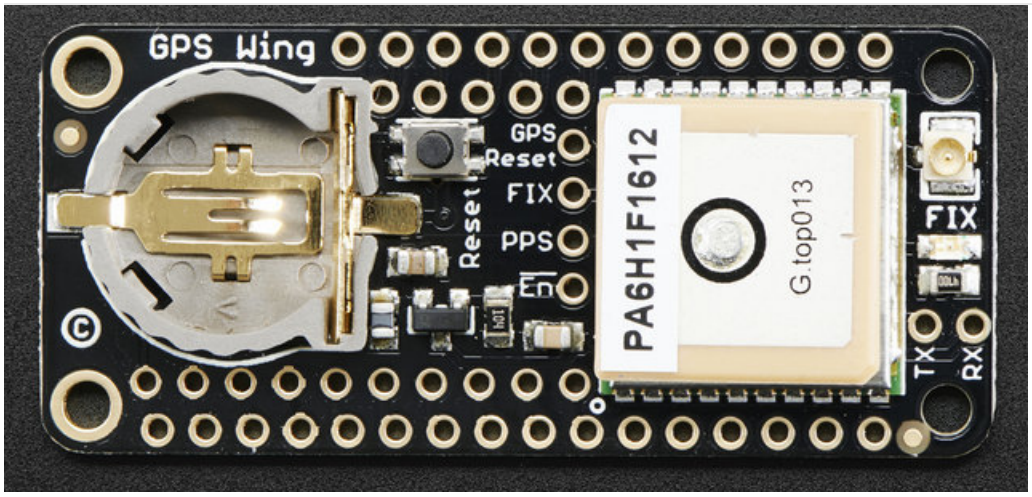
- Satellites: 22 tracking, 66 searching
- Patch Antenna Size: 15mm x 15mm x 4mm
- Update rate: 1 to 10 Hz
- Position Accuracy: 1.8 meters
- Velocity Accuracy: 0.1 meters/s
- Warm/cold start: 34 seconds
- Acquisition sensitivity: -145 dBm
- Tracking sensitivity: -165 dBm
- Maximum Velocity: 515m/s
- Vin range: 3.0-5.5VDC
- MTK3339 Operating current: 25mA tracking, 20 mA current draw during navigation
- Output: NMEA 0183, 9600 baud default
- DGPS/WAAS/EGNOS supported
- FCC E911 compliance and AGPS support (Offline mode : EPO valid up to 14 days)
- Up to 210 PRN channels
- Jammer detection and reduction

- Multi-path detection and compensation

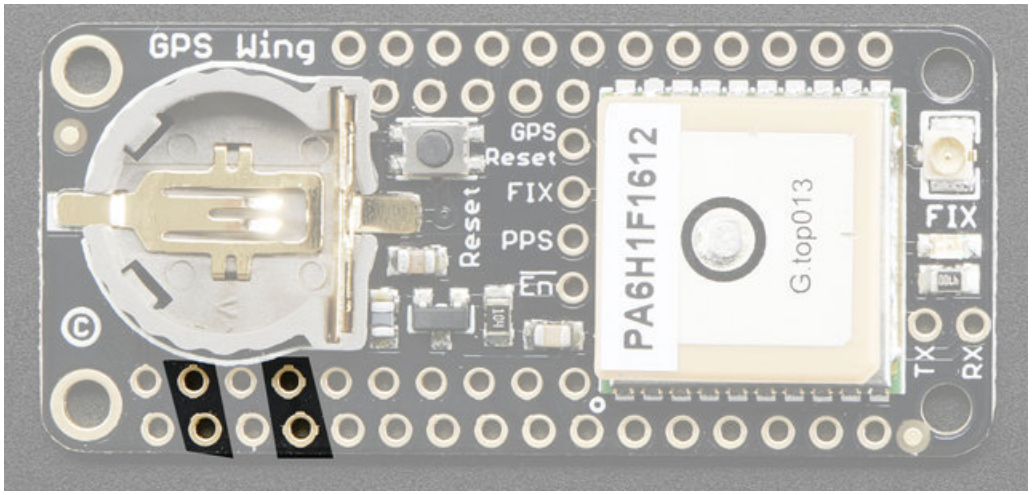


Comes as a fully assembled FeatherWing with GPS module and a coin cell holder. However, the 12mm coin cell is**not included** - it isn't required but if you would like a battery backup, a CR1220 coin battery must be purchased seperately. We also toss in some header so you can solder it in and plug into your Feather

Pinouts

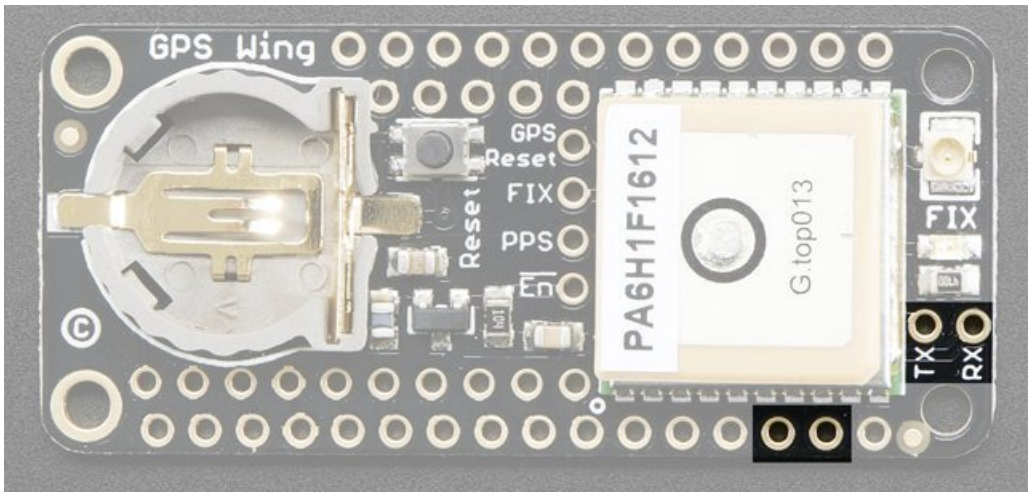


Power Pins



The GPS module runs from +3.3V power and uses 3V logic. the GPS is powered directly from the **3V** and **GND** pins on the bottom left of the Feather. Each Feather has a regulator to provide clean 3V power from USB or battery power.

Serial Data Pins

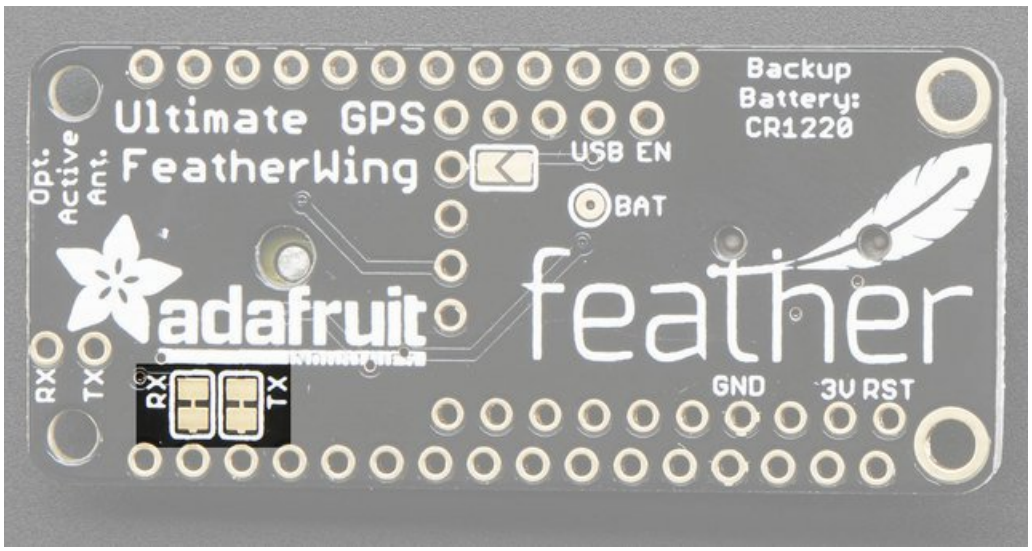


The GPS module, like pretty much all GPS's, communicates over UART serial. It sends ASCII NMEA setences from the GPS TX pin to the microcontroller RX pin and can be controlled to change its data output from the GPS RX pin. Logic level is 3.3V for both.

The baud rate by default is 9600 baud, but you can configure the module to use different baud rate if desired

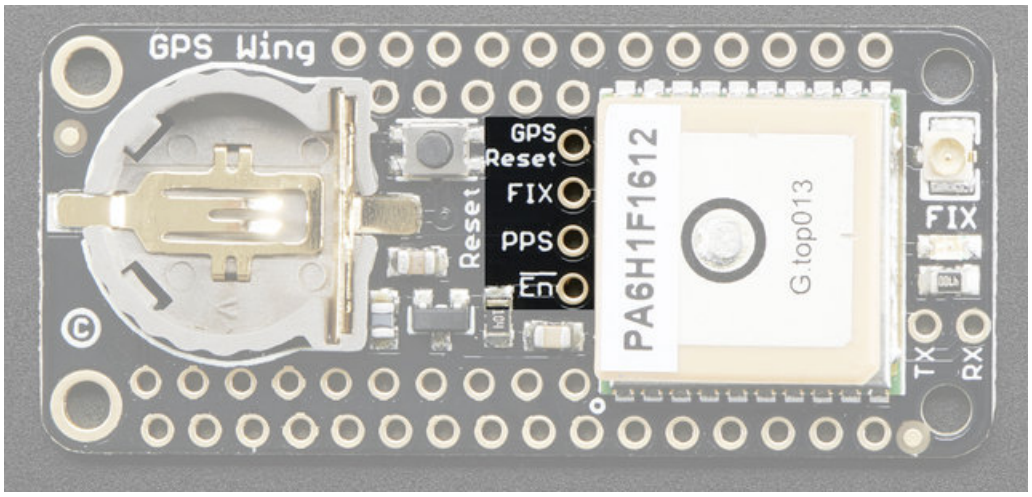
The GPS is wired directly to the Serial pins at the bottom right of the Feather. **Note that on the ESP8266 Feather this is used for bootloading so the GPS module is not recommended for use with the ESP8266!** The other Feathers use USB for bootloading, so the hardware Serial port is available.

If you need to connect to a different set of pins, you can cut the RX and TX jumpers on the bottom of the board



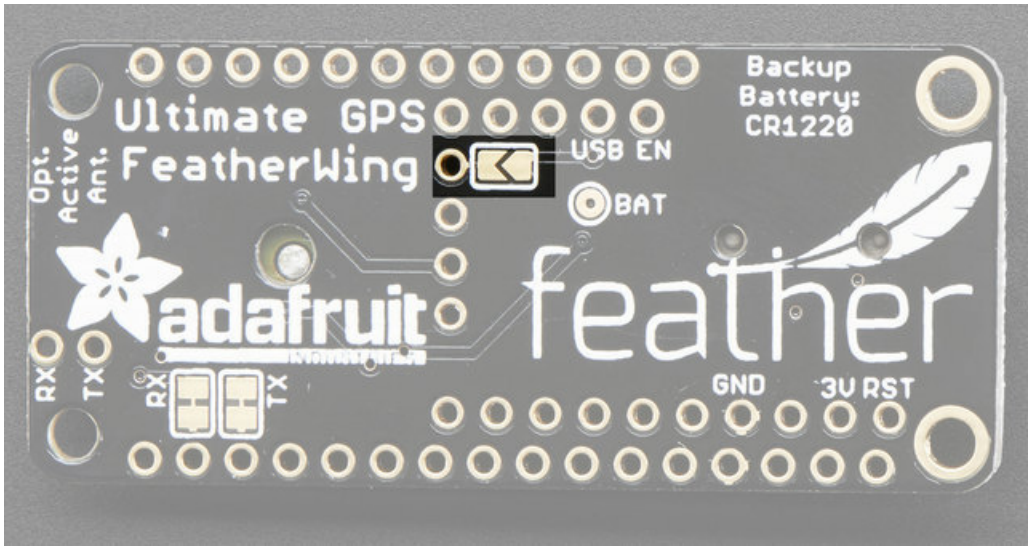
And then wire your desired pins to the RX and TX breakouts right next to the **FIX** LED

GPS Breakouts



The GPS module has some more pins you can use:

GPS Reset - you can use this to manually reset the GPS module if you set the baud rate to something inscrutable or you just want to 'kick it'. Reset by pulling low. Note that pulling reset low does not put the GPS into a low power state, you'll want to disable it instead (see EN). There's a jumper on the back if you want to connect the GPS reset to the microcontroller reset line

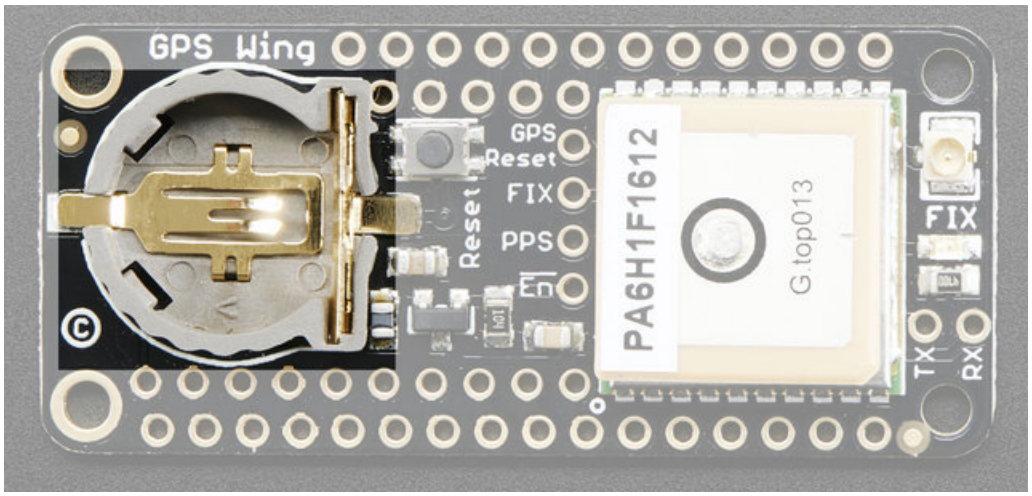


FIX is an output pin - it is the same pin as the one that drives the red FIX LED. When there is no fix, the FIX pin is going to pulse up and down once every second. When there is a fix, the pin is low (0V) for most of the time, once every 15 seconds it will pulse high for 200 milliseconds

PPS is a "pulse per second" output. Most of the time it is at logic low (ground) and then it pulses high (3.3V) once a second, for 50-100ms, so it should be easy for a microcontroller to sync up to it

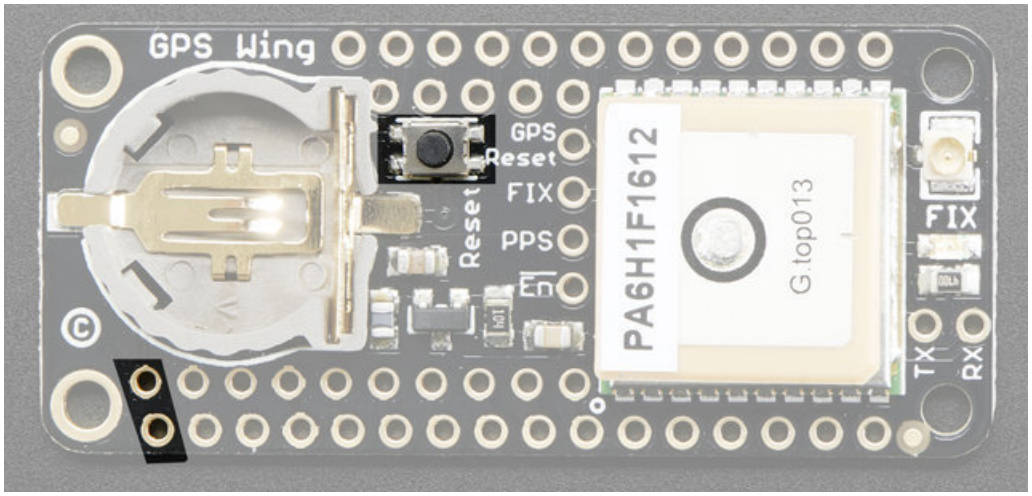
EN is a true 'power disable' control line you can use to completely cut power to the GPS module. This is good if you need to run at ultra-low-power modes. By default this is pulled low (enabled). So pull high to disable the GPS.

Coin Battery



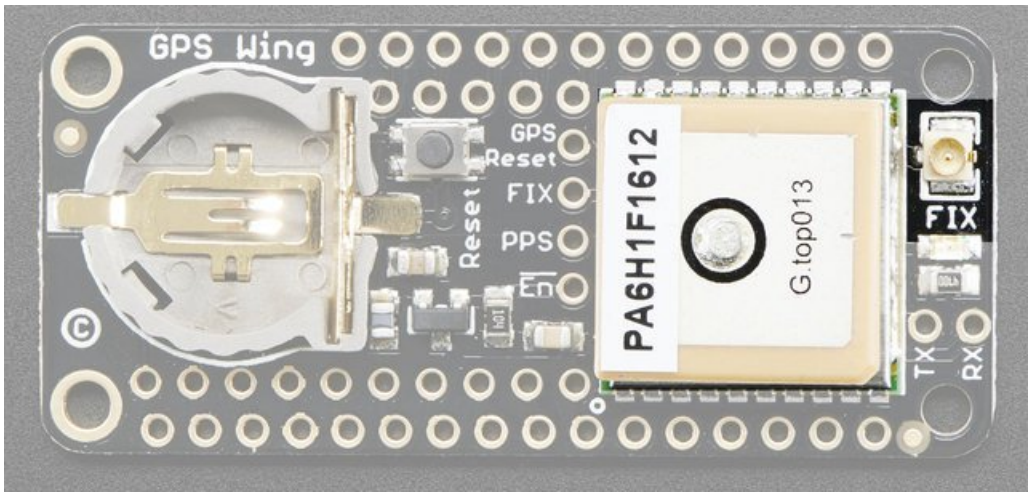
The GPS does not *require* but does benefit by having a coin cell backup battery. You can install any "CR1220" sized battery into the holder. The GPS will automatically detect the battery and use it as a backup for the ephemeris memory

Reset Button



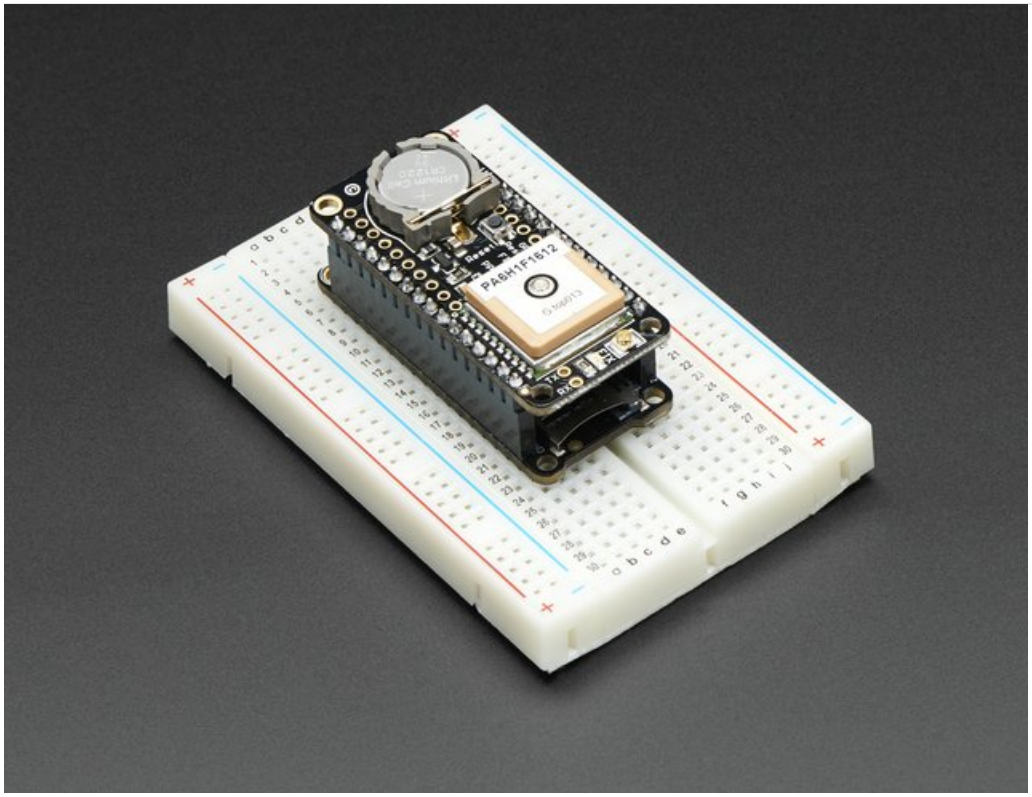
There is a small button that will connect the *microcontroller* RESET pin to ground for resetting it. Handy to restart the Feather. Note that this is not connected to GPS reset unless you short the jumper on the back!

Antennas



You have two options for an antenna. The GPS module has an antenna on it already, that's the square tan ceramic thing on the left side. If you plug an *active GPS antenna* into the uFL connector on the very right, the module will automatically switch over to the external antenna.

Basic RX-TX Test



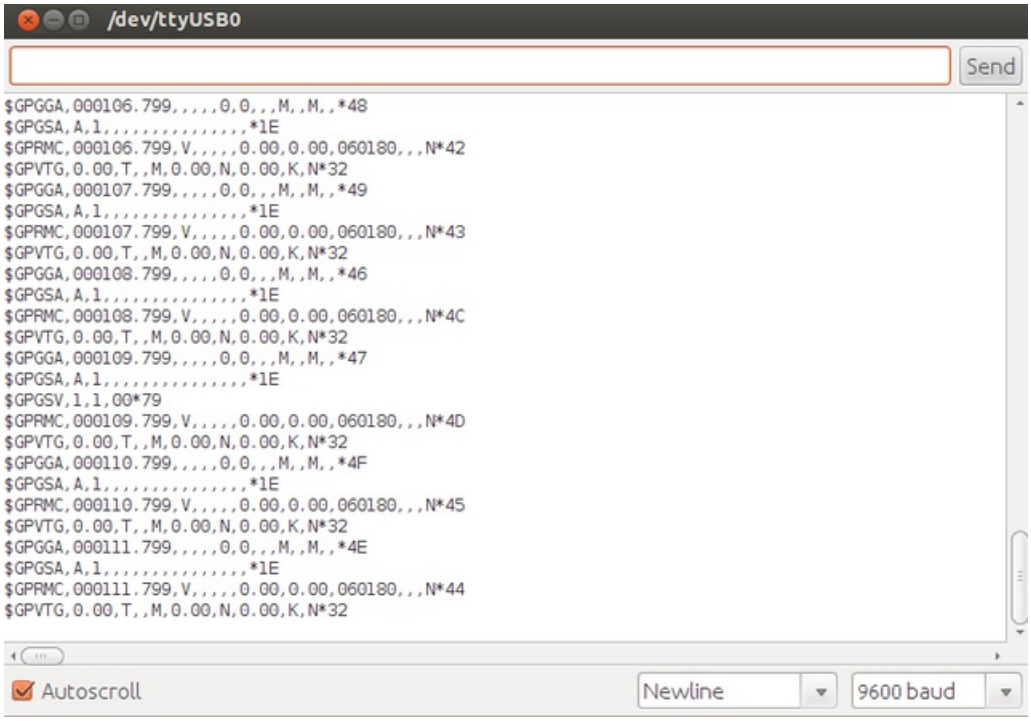
The first, and simplest test, is just to echo data back and forth using the Feather's USB connection to read the GPS data out. The nice thing about this demo is no library is required.

This doesn't work with the ESP8266 or nRF52 Feather!

Upload the following to your Feather, it will work with the Feather 32u4, M0, WICED, etc. Anything that does not have the RX/TX pins used to communicate.

```
// test a passthru between USB and hardware serial

void setup() {
  Serial.println("GPS echo test");
  Serial.begin(9600);
  Serial1.begin(9600);      // default NMEA GPS baud
}


void loop() {
  if (Serial.available()) {
    char c = Serial.read();
    Serial1.write(c);
  }
  if (Serial1.available()) {
    char c = Serial1.read();
    Serial.write(c);
  }
}
```

Now open up the serial monitor from the Arduino IDE and be sure to select **9600 baud** in the drop down. You should see text like the following:



This is the raw GPS "NMEA sentence" output from the module. There are a few different kinds of NMEA sentences, the most common ones people use are the **$GPRMC** (**G**lobal **P**ositioning **R**ecommended**M**inimum **C**oordinates or something like that) and the **$GPGGA** sentences. These two provide the time, date, latitude, longitude, altitude, estimated land speed, and fix type. Fix type indicates whether the GPS has locked onto the satellite data and received enough data to determine the location (2D fix) or location+altitude (3D fix).

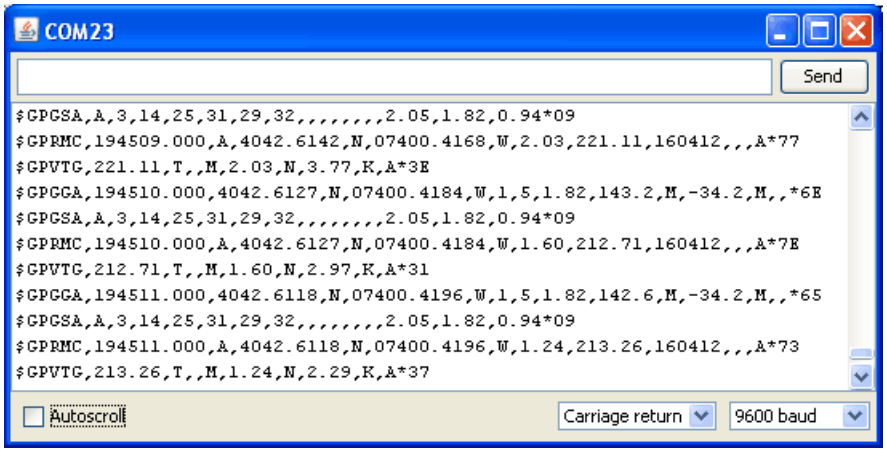
For more details about NMEA sentences and what data they contain, check out this site

If you look at the data in the above window, you can see that there are a lot of commas, with no data in between them.

That's because this module is on my desk, indoors, and does not have a 'fix'. To get a fix, we need to put the module outside.

> GPS modules will always send data EVEN IF THEY DO NOT HAVE A FIX! In order to get 'valid' (not-blank) data you must have the GPS module directly outside, with the square ceramic antenna pointing up with a clear sky view. In ideal conditions, the module can get a fix in under 45 seconds. however depending on your location, satellite configuration, solar flares, tall buildings nearby, RF noise, etc it may take up to half an hour (or more) to get a fix! This does not mean your GPS module is broken, the GPS module will always work as fast as it can to get a fix.

If you can get a really long USB cord (or attach a GPS antenna) and stick the GPS out a window, so its pointing at the sky, eventually the GPS will get a fix and the window data will change over to transmit valid data like this:



Look for the line that says **$GPRMC,194509.000,A,4042.6142,N,07400.4168,W,2.03,221.11,160412,,,A*77**
This line is called the RMC (Recommended Minimum) sentence and has pretty much all of the most useful data. Each chunk of data is separated by a comma.

The first part **194509.000** is the current time **GMT** (Greenwich Mean Time). The first two numbers **19** indicate the hour (1900h, otherwise known as 7pm) the next two are the minute, the next two are the seconds and finally the milliseconds. So the time when this screenshot was taken is 7:45 pm and 9 seconds. The GPS does not know what time zone you are in, or about "daylight savings" so you will have to do the calculation to turn GMT into your timezone

The second part is the 'status code', if it is a **V** that means the data is **V**oid (invalid). If it is an **A** that means its **A**ctive (the GPS could get a lock/fix)

The next 4 pieces of data are the geolocation data. According to the GPS, my location is **4042.6142,N** (Latitude 40 degrees, 42.6142 decimal minutes North) & **07400.4168,W**. (Longitude 74 degrees, 0.4168 decimal minutes West) To look at this location in Google maps, type **+40 42.6142', -74 00.4168'** into the google maps search box . Unfortunately gmaps requires you to use +/- instead of NSWE notation. N and E are positive, S and W are negative.

> People often get confused because the GPS is working but is "5 miles off" - this is because they are not parsing the lat/long data correctly. Despite appearances, the geolocation data is NOT in decimal degrees. It is in degrees and minutes in the following format: Latitude: DDMM.MMMM (The first two characters are the degrees.) Longitude: DDDMM.MMMM (The first three characters are the degrees.)

The next data is the ground speed in knots. We're going **2.03** knots

After that is the tracking angle, this is meant to approximate what 'compass' direction we're heading at based on our past travel

The one after that is **160412** which is the current date (16th of April, 2012).

Finally there is the ***XX** data which is used as a data transfer checksum

Once you get a fix using your GPS module, verify your location with google maps (or some other mapping software). Remember that GPS is often only accurate to 5-10 meters and worse if you're indoors or surrounded by tall buildings.

Arduino Library

Once you've gotten the GPS module tested with direct rx-tx, we can go forward and do some more advanced parsing.

Download the Adafruit GPS library. This library does a lot of the 'heavy lifting' required for receiving data from GPS modules, such as reading the streaming data in a background interrupt and auto-magically parsing it. To download it, visit the GitHub repository or just click below

Download Adafruit GPS Library

https://adafru.it/emg

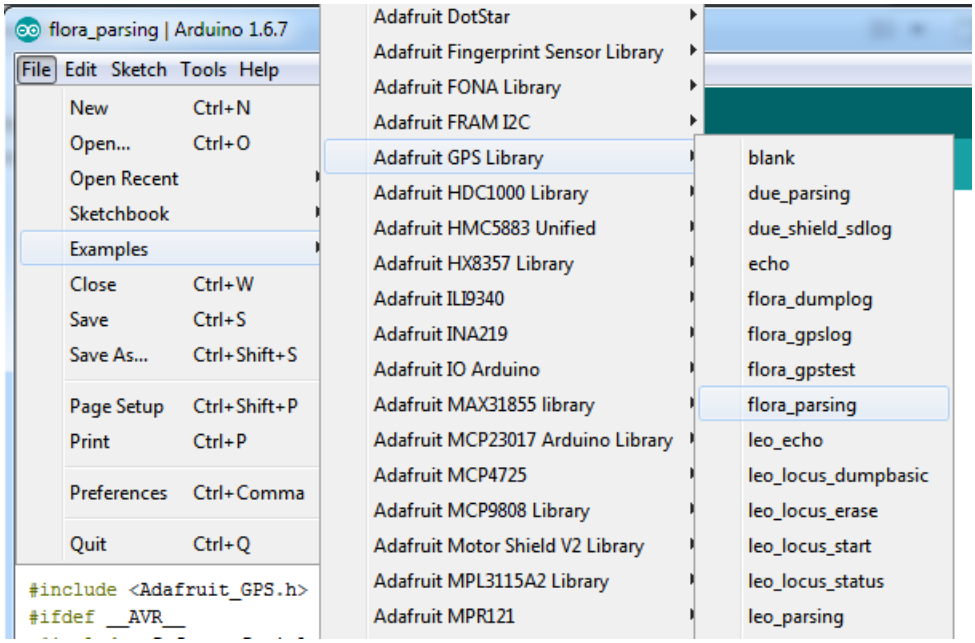
Rename the uncompressed folder **Adafruit_GPS**. Check that the **Adafruit_GPS** folder contains **Adafruit_GPS.cpp** and **Adafruit_GPS.h**

Move **Adafruit_GPS** to your Arduino/Libraries folder and restart the Arduino IDE. Library installation is a frequent stumbling block...if you need assistance, our All About Arduino Libraries guide spells it out in detail!

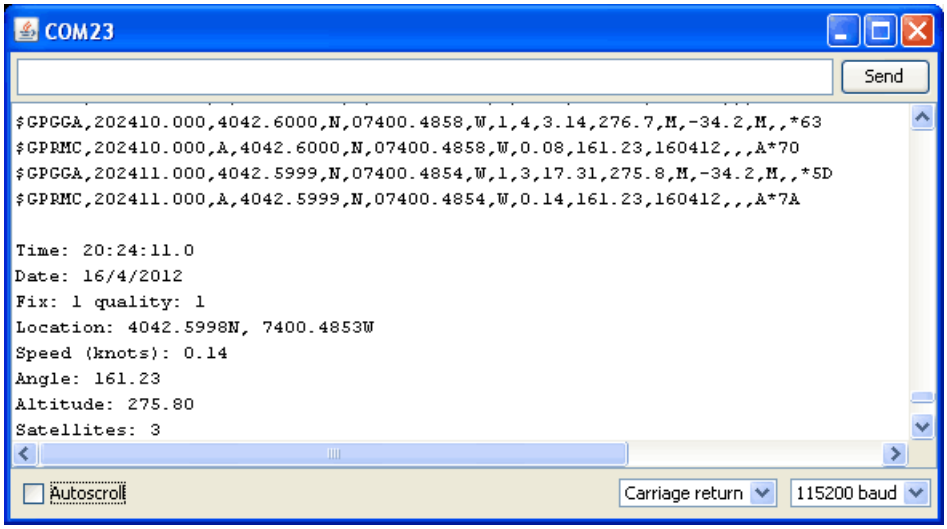
Parsed Data

Since all GPS's output NMEA sentences and often for our projects we need to extract the actual data from them, we've simplified the task tremendously when using the Adafruit GPS library. By having the library read, store and parse the data in a background interrupt it becomes trivial to query the library and get the latest updated information without any icky parsing work.

Open up the **File→Examples→Adafruit_GPS→flora_parsing** sketch and upload it to the Arduino.



Then open up the serial monitor.



In this sketch, we call **GPS.read()** constantly in the main loop (if you can, get this to run once a millisecond in an interrupt). Then in the main loop we can ask if a new chunk of data has been received by calling **GPS.newNMEAreceived()**, if this returns **true** then we can ask the library to parse that data with **GPS.parse(GPS.lastNMEA())**.

We do have to keep querying and parsing in the main loop - its not possible to do this in an interrupt because then we'd be dropping GPS data by accident.

Once data is parsed, we can just ask for data from the library like **GPS.day**, **GPS.month** and **GPS.year** for the current date. **GPS.fix** will be 1 if there is a fix, 0 if there is none. If we have a fix then we can ask for **GPS.latitude**, **GPS.longitude**, **GPS.speed** (in knots, not mph or k/hr!), **GPS.angle**, **GPS.altitude** (in meters) and **GPS.satellites** (number of satellites)

This should make it much easier to have location-based projects. We suggest keeping the update rate at 1Hz and request that the GPS only output RMC and GGA as the parser does not keep track of other data anyways.

CircuitPython Library

You can easily use a GPS module like the ultimate GPS FeatherWing with CircuitPython code. Python code is well suited for parsing and processing the text output from GPS modules and this Adafruit CircuitPython GPS module handles most of the work for you!

First make sure your Feather is running CircuitPython firmware, and the GPS FeatherWing is assembled and connected to the Feather board. By default the FeatherWing will automatically use the Feather's RX and TX pins for a hardware serial connection.

Note: Just like with Arduino the ESP8266 Feather shares its serial RX and TX pins with the USB serial connection and can be difficult to use with GPS modules. In particular you won't be able to use the REPL and other core tools like ampy to copy files if a GPS FeatherWing is connected. It's recommended not to use the ESP8266 with the GPS FeatherWing.

Next you'll need to install the Adafruit CircuitPython GPS library on your CircuitPython board. **Remember this module is for Adafruit CircuitPython firmware and not MicroPython.org firmware!**

First make sure you are running the latest version of Adafruit CircuitPython 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. For example the Circuit Playground Express guide has a great page on how to install the library bundle for both express and non-express boards.

Remember for non-express boards like the Trinket M0, Gemma M0, and Feather/Metro M0 basic you'll need to manually install the necessary libraries from the bundle:

- **adafruit_gps.mpy**

You can also download the **adafruit_gps.mpy** file from the Adafruit CircuitPython GPS releases page.

Before continuing make sure your board's lib folder or root filesystem has the **adafruit_gps.mpy,** files and folders copied over.

Usage

To demonstrate the usage of the GPS module in CircuitPython let's look at a complete program example. the simple.py file from the module's examples. Save this file as **main.py** on your board, then open the REPL connection to the board to see its output:

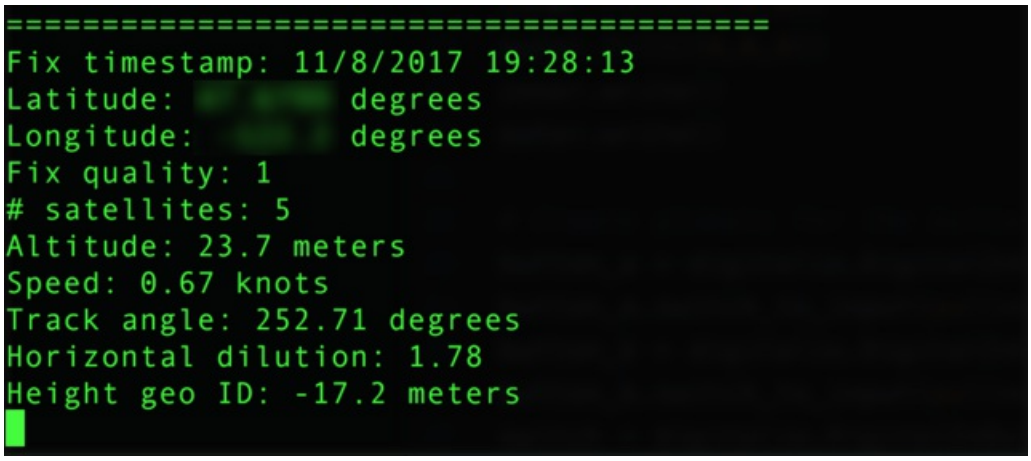
```
# Simple GPS module demonstration.
# Will wait for a fix and print a message every second with the current location
# and other details.
import board
import busio
import time

import adafruit_gps


# Define RX and TX pins for the board's serial port connected to the GPS.
# These are the defaults you should use for the GPS FeatherWing.
# For other boards set RX = GPS module TX, and TX = GPS module RX pins.
RX = board.RX
```

```
TX = board.TX

# Create a serial connection for the GPS connection using default speed and
# a slightly higher timeout (GPS modules typically update once a second).
uart = busio.UART(TX, RX, baudrate=9600, timeout=3000)

# Create a GPS module instance.
gps = adafruit_gps.GPS(uart)

# Initialize the GPS module by changing what data it sends and at what rate.
# These are NMEA extensions for PMTK_314_SET_NMEA_OUTPUT and
# PMTK_220_SET_NMEA_UPDATERATE but you can send anything from here to adjust
# the GPS module behavior:
#   https://cdn-shop.adafruit.com/datasheets/PMTK_A11.pdf

# Turn on the basic GGA and RMC info (what you typically want)
gps.send_command('PMTK314,0,1,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Turn on just minimum info (RMC only, location):
#gps.send_command('PMTK314,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Turn off everything:
#gps.send_command('PMTK314,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Tuen on everything (not all of it is parsed!)
#gps.send_command('PMTK314,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0')

# Set update rate to once a second (1hz) which is what you typically want.
gps.send_command('PMTK220,1000')
# Or decrease to once every two seconds by doubling the millisecond value.
# Be sure to also increase your UART timeout above!
#gps.send_command('PMTK220,2000')
# You can also speed up the rate, but don't go too fast or else you can lose
# data during parsing.  This would be twice a second (2hz, 500ms delay):
#gps.send_command('PMTK220,500')

# Main loop runs forever printing the location, etc. every second.
last_print = time.monotonic()
while True:
    # Make sure to call gps.update() every loop iteration and at least twice
    # as fast as data comes from the GPS unit (usually every second).
    # This returns a bool that's true if it parsed new data (you can ignore it
    # though if you don't care and instead look at the has_fix property).
    gps.update()
    # Every second print out current location details if there's a fix.
    current = time.monotonic()
    if current - last_print >= 1.0:
        last_print = current
        if not gps.has_fix:
            # Try again if we don't have a fix yet.
            print('Waiting for fix...')
            continue
        # We have a fix! (gps.has_fix is true)
        # Print out details about the fix like location, date, etc.
        print('=' * 40)  # Print a separator line.
        print('Fix timestamp: {}/{}/{} {:02}:{:02}:{:02}'.format(
                gps.timestamp_utc.tm_mon,   # Grab parts of the time from the
                gps.timestamp_utc.tm_mday,  # struct_time object that holds
                gps.timestamp_utc.tm_year,  # the fix time.  Note you might
                gps.timestamp_utc.tm_hour,  # not get all data like year, day,
                gps.timestamp_utc.tm_min,   # month!
                gps.timestamp_utc.tm_sec))
        print('Latitude: {} degrees'.format(gps.latitude))
```

```
        print('Longitude: {} degrees'.format(gps.longitude))
        print('Fix quality: {}'.format(gps.fix_quality))
        # Some attributes beyond latitude, longitude and timestamp are optional
        # and might not be present.  Check if they're None before trying to use!
        if gps.satellites is not None:
            print('# satellites: {}'.format(gps.satellites))
        if gps.altitude_m is not None:
            print('Altitude: {} meters'.format(gps.altitude_m))
        if gps.track_angle_deg is not None:
            print('Speed: {} knots'.format(gps.speed_knots))
        if gps.track_angle_deg is not None:
            print('Track angle: {} degrees'.format(gps.track_angle_deg))
        if gps.horizontal_dilution is not None:
            print('Horizontal dilution: {}'.format(gps.horizontal_dilution))
        if gps.height_geoid is not None:
            print('Height geo ID: {} meters'.format(gps.height_geoid))
```

When the code runs it will print a message every second to the REPL, either an update that it's still waiting for a GPS fix:

Or once a fix has been established (make sure the GPS module has a good view of the sky!) it will print details about the current location and other GPS data:



Let's look at the code in a bit more detail to understand how it works. First the example needs to import a few modules like the built-in **busio** and **board** modules that access serial ports and other hardware:

```
import board
import busio
import time
```

Next the GPS module is imported:

```
import adafruit_gps
```

Now a serial UART is created and connected to the serial port pins the GPS module will use, this is the low level transport layer to communicate with the GPS module:

```
# Define RX and TX pins for the board's serial port connected to the GPS.
# These are the defaults you should use for the GPS FeatherWing.
# For other boards set RX = GPS module TX, and TX = GPS module RX pins.
RX = board.RX
TX = board.TX

# Create a serial connection for the GPS connection using default speed and
# a slightly higher timeout (GPS modules typically update once a second).
uart = busio.UART(TX, RX, baudrate=9600, timeout=3000)
```

Once a UART object is available with a connected GPS module you can create an instance of the GPS parsing class. You need to pass this class the UART instance and it will internally read new data from the GPS module connected to it:

```
gps = adafruit_gps.GPS(uart)
```

Before reading GPS data the example configures the module by sending some custom NMEA GPS commands that adjust the amount and rate of data. Read the comments to see some options for adjust the rate and amount of data, but typically you want the defaults of core location info at a rate of once a second:

```
# Initialize the GPS module by changing what data it sends and at what rate.
# These are NMEA extensions for PMTK_314_SET_NMEA_OUTPUT and
# PMTK_220_SET_NMEA_UPDATERATE but you can send anything from here to adjust
# the GPS module behavior:
#   https://cdn-shop.adafruit.com/datasheets/PMTK_A11.pdf

# Turn on the basic GGA and RMC info (what you typically want)
gps.send_command('PMTK314,0,1,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Turn on just minimum info (RMC only, location):
#gps.send_command('PMTK314,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Turn off everything:
#gps.send_command('PMTK314,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0')
# Tuen on everything (not all of it is parsed!)
#gps.send_command('PMTK314,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0')

# Set update rate to once a second (1hz) which is what you typically want.
gps.send_command('PMTK220,1000')
# Or decrease to once every two seconds by doubling the millisecond value.
# Be sure to also increase your UART timeout above!
#gps.send_command('PMTK220,2000')
# You can also speed up the rate, but don't go too fast or else you can lose
# data during parsing.  This would be twice a second (2hz, 500ms delay):
#gps.send_command('PMTK220,500')
```

If you want you can send other custom commands to the GPS module with the **send_command** function shown

above. You don't need to worry about adding a NMEA checksum to your command either, the function will do this automatically (or not, set **add_checksum=False** as a parameter and it will skip the checksum addition).

Now we can jump into a main loop that continually updates data from the GPS module and prints out status. The most important part of this loop is calling the GPS update function:

```
# Make sure to call gps.update() every loop iteration and at least twice
# as fast as data comes from the GPS unit (usually every second).
# This returns a bool that's true if it parsed new data (you can ignore it
# though if you don't care and instead look at the has_fix property).
gps.update()
```

Like the comments mention you must call updated every loop iteration and ideally multiple times a second. Each time you call update it allows the GPS library code to read new data from the GPS module and update its state. Since the GPS module is always sending data you have to be careful to constantly read data or else you might start to lose data as buffers are filled.

You can check the **has_fix** property to see if the module has a GPS location fix, and if so there are a host of attributes to read like **latitude** and **longitude** (available in degrees):

```
        if not gps.has_fix:
            # Try again if we don't have a fix yet.
            print('Waiting for fix...')
            continue
        # We have a fix! (gps.has_fix is true)
        # Print out details about the fix like location, date, etc.
        print('=' * 40)  # Print a separator line.
        print('Fix timestamp: {}/{}/{} {:02}:{:02}:{:02}'.format(
                gps.timestamp_utc.tm_mon,   # Grab parts of the time from the
                gps.timestamp_utc.tm_mday,  # struct_time object that holds
                gps.timestamp_utc.tm_year,  # the fix time.  Note you might
                gps.timestamp_utc.tm_hour,  # not get all data like year, day,
                gps.timestamp_utc.tm_min,   # month!
                gps.timestamp_utc.tm_sec))
        print('Latitude: {} degrees'.format(gps.latitude))
        print('Longitude: {} degrees'.format(gps.longitude))
        print('Fix quality: {}'.format(gps.fix_quality))
        # Some attributes beyond latitude, longitude and timestamp are optional
        # and might not be present.  Check if they're None before trying to use!
        if gps.satellites is not None:
            print('# satellites: {}'.format(gps.satellites))
        if gps.altitude_m is not None:
            print('Altitude: {} meters'.format(gps.altitude_m))
        if gps.track_angle_deg is not None:
            print('Speed: {} knots'.format(gps.speed_knots))
        if gps.track_angle_deg is not None:
            print('Track angle: {} degrees'.format(gps.track_angle_deg))
        if gps.horizontal_dilution is not None:
            print('Horizontal dilution: {}'.format(gps.horizontal_dilution))
        if gps.height_geoid is not None:
```

Notice some of the attributes like **altitude_m** are checked to be None before reading. This is a smart check to put in your code too because those attributes are sometimes not sent by a GPS module. If an attribute isn't sent by the module it will be given a None/null value and attempting to print or read it in Python will fail. The core attributes of

latitude, **longitude**, and **timestamp** are usually always available (if you're using the example as-is) but they might not be if you turn off those outputs with a custom NMEA command!

That's all there is to reading GPS location with CircuitPython code!

Datalogging Example

Another handy task with GPS is logging all the raw output of the GPS module to a file. This is useful if you're importing the GPS data into a tool like Google Earth which can process raw NMEA sentences. You can perform this datalogging very easily with CircuitPython.

To store data you'll need to choose one of two options:

- Wire up a SD card holder to your board's SPI bus, or use a board with SD card holder built-in like the Feather M0 Adalogger. **This is the recommended approach** as it gives you a lot of space to store data and you can easily copy the data to your computer from the card.
- Store data in your board's internal filesystem. This requires a little more setup but allows you to save to a file on the internal filesystem of your CircuitPython board, right next to where code and other data files live. This is more limited because depending on your board you might only have a few kilobytes or megabytes of space available and GPS sentences will quickly add up (easily filling multiple megabytes within a few hours of logging).

Install SD Card Library

If you're storing data on a SD card you must ensure the SD card is wired to your board and you have installed the Adafruit SD card library. Luckily there's an entire guide to follow to learn about this process of connecting a SD card and installing the necessary library. Be sure to carefully follow the guide so the card is connected, library installed, and you can confirm you're able to manually write data to the card from the Python prompt.

Enable Internal Filesystem Writes

If you're storing data on the internal filesystem you **must** carefully follow the steps in the CPU temperature logging guide to enable writing to internal storage. **If you're writing to a SD card skip these steps and move on to look at the datalogging code below.** Edit the **boot.py** on your board (creating it if it doesn't exist) and add these lines:

```
import digitalio
import board
import storage

switch = digitalio.DigitalInOut(board.D5)
switch.direction = digitalio.Direction.INPUT
switch.pull = digitalio.Pull.UP

# If the D5 is connected to ground with a wire
# you can edit files over the USB drive again.
storage.remount("/", not switch.value)
```

Remember once you remount("/") **you cannot edit code over the USB drive anymore!** That means you can't edit **boot.py** which is a bit of a conundrum. So we configure the **boot.py** to selectively mount the internal filesystem as writable based on a switch or even just alligator clip connected to ground. Like the CPU temperature guide shows . In this example we're using **D5** but select any available pin.

This code will look at the D5 digital input when the board starts up and if it's connected to ground (use an alligator clip or wire, for example, to connect from D5 to board ground) it will disable internal filesystem writes and allow you to edit code over the USB drive as normal. Remove the alligator clip, reset the board, and the **boot.py** will switch to mounting

the internal filesystem as writable so you can log images to it again (but not write any code!).

Remember when you enable USB drive writes (by connecting D5 to ground at startup) you **cannot write files** to the internal filesystem and any code in your **main.py** that attempts to do so (like the example below) will fail. Keep this in mind as you edit code--once you modify code you need to remove the alligator clip, reset the board to re-enable internal filesystem writes, and then watch the output of your program.

> If you ever get stuck, you can follow the steps mentioned in https://learn.adafruit.com/cpu-temperature-logging-with-circuit-python/writing-to-the-filesystem to remove boot.py from the REPL if you need to go back and edit code!

Datalogging Example Code

The GPS library examples have a **datalogging.py** file you can edit and save as a **main.py** on your board:

```
# Simple GPS datalogging demonstration.
# This actually doesn't even use the GPS library and instead just reads raw
# NMEA sentences from the GPS unit and dumps them to a file on an SD card
# (recommended) or internal storage (be careful as only a few kilobytes to
# megabytes are available).  Before writing to internal storage you MUST
# carefully follow the steps in this guide to enable writes to the internal
# filesystem:
#  https://learn.adafruit.com/adafruit-ultimate-gps-featherwing/circuitpython-library
import board
import busio


# Path to the file to log GPS data.  By default this will be appended to
# which means new lines are added at the end and all old data is kept.
# Change this path to point at internal storage (like '/gps.txt') or SD
# card mounted storage ('/sd/gps.txt') as desired.
LOG_FILE = '/gps.txt'  # Example for writing to internal path /gps.txt
#LOG_FILE = '/sd/gps.txt'     # Example for writing to SD card path /sd/gps.txt

# File more for opening the log file.  Mode 'ab' means append or add new lines
# to the end of the file rather than erasing it and starting over.  If you'd
# like to erase the file and start clean each time use the value 'wb' instead.
LOG_MODE = 'ab'

# Define RX and TX pins for the board's serial port connected to the GPS.
# These are the defaults you should use for the GPS FeatherWing.
# For other boards set RX = GPS module TX, and TX = GPS module RX pins.
RX = board.RX
TX = board.TX

# If writing to SD card customize and uncomment these lines to import the
# necessary library and initialize the SD card:
#SD_CS_PIN = board.SD_CS  # CS for SD card (SD_CS is for Feather Adalogger)
#import adafruit_sdcard
#spi = busio.SPI(board.SCK, MOSI=board.MOSI, MISO=board.MISO)
#sd_cs = digitalio.DigitalInOut(SD_CS_PIN)
#sdcard = adafruit_sdcard.SDCard(spi, sd_cs)
#vfs = storage.VfsFat(sdcard)
#storage.mount(vfs, '/sd')  # Mount SD card under '/sd' path in filesystem.

# Create a serial connection for the GPS connection using default speed and
# a slightly higher timeout (GPS modules typically update once a second).
uart = busio.UART(TX, RX, baudrate=9600, timeout=3000)

# Main loop just reads data from the GPS module and writes it back out to
# the output file while also printing to serial output.
with open(LOG_FILE, LOG_MODE) as outfile:
    while True:
        sentence = uart.readline()
        print(str(sentence, 'ascii').strip())
        outfile.write(sentence)
        outfile.flush()
```

By default this example expects to log GPS NMEA sentences to a file on the internal storage system at **/gps.txt**. New sentences will be appended to the end of the file every time the example starts running.

If you'd like to instead write to the SD card take note to uncomment the appropriate lines mentioned in the comments:

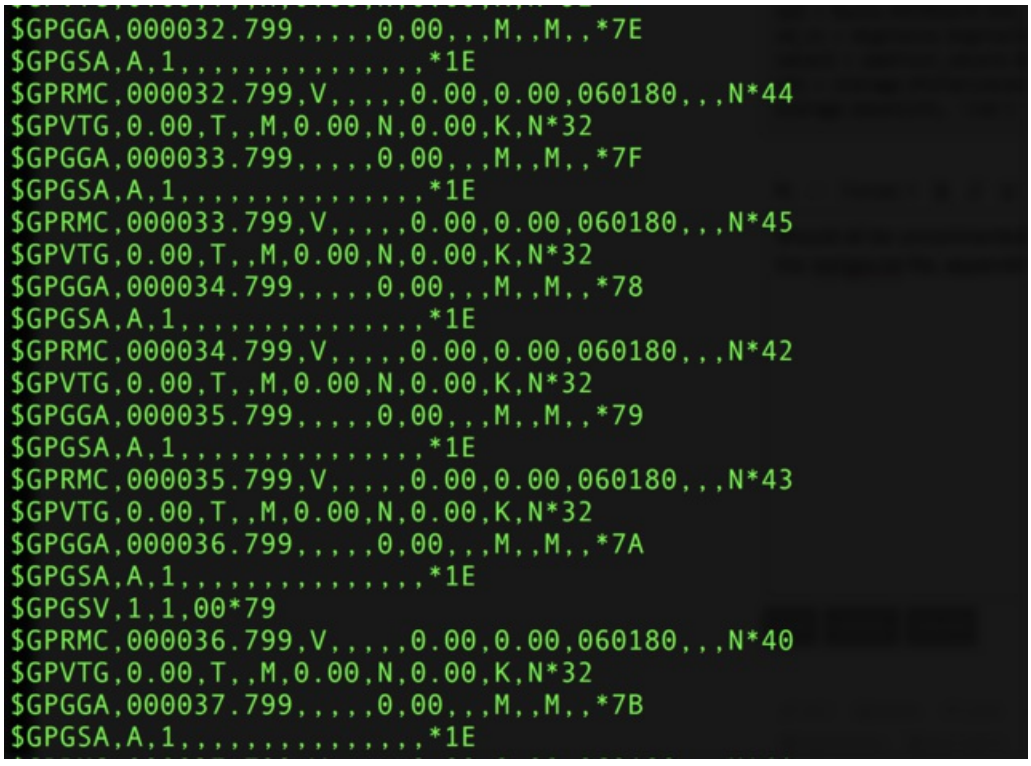
```
# Path to the file to log GPS data.  By default this will be appended to
# which means new lines are added at the end and all old data is kept.
# Change this path to point at internal storage (like '/gps.txt') or SD
# card mounted storage ('/sd/gps.txt') as desired.
#LOG_FILE = '/gps.txt'  # Example for writing to internal path /gps.txt
LOG_FILE = '/sd/gps.txt'     # Example for writing to SD card path /sd/gps.txt
```

And further below:

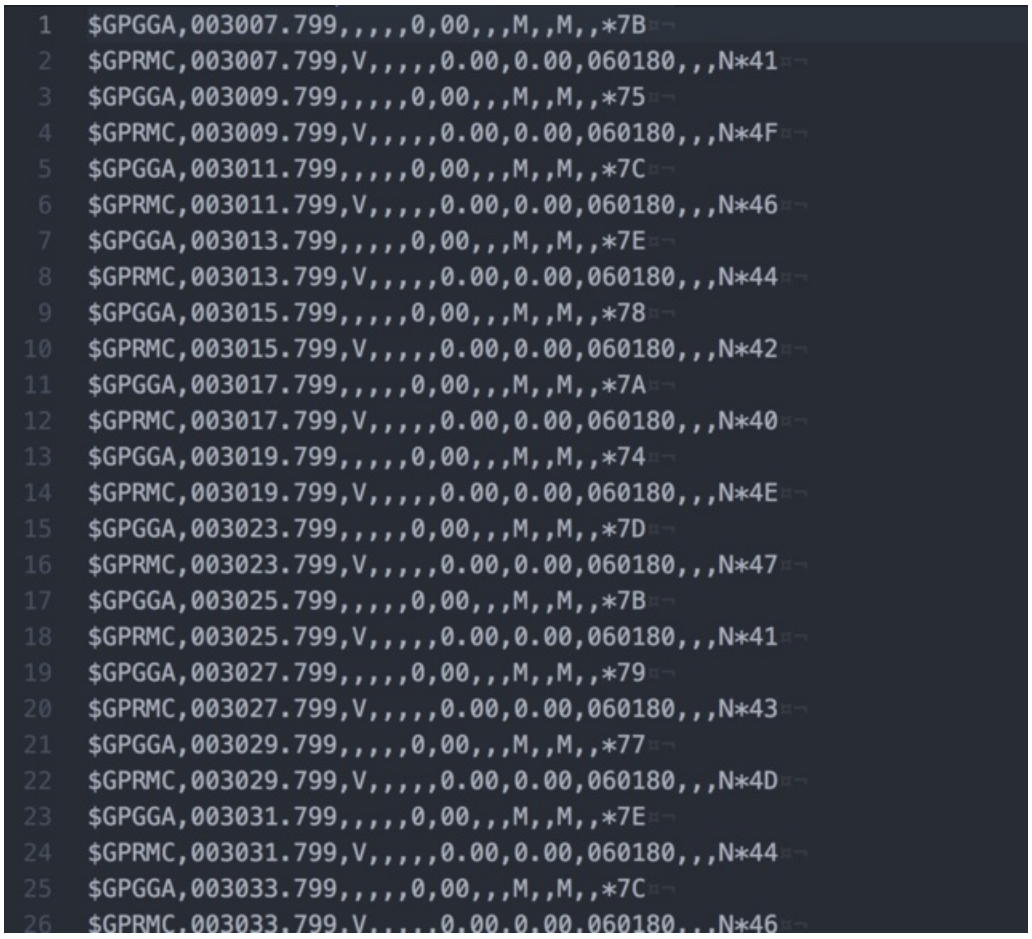
```
# If writing to SD card customize and uncomment these lines to import the
# necessary library and initialize the SD card:
SD_CS_PIN = board.SD_CS  # CS for SD card (SD_CS is for Feather Adalogger)
import adafruit_sdcard
spi = busio.SPI(board.SCK, MOSI=board.MOSI, MISO=board.MISO)
sd_cs = digitalio.DigitalInOut(SD_CS_PIN)
sdcard = adafruit_sdcard.SDCard(spi, sd_cs)
vfs = storage.VfsFat(sdcard)
storage.mount(vfs, '/sd')  # Mount SD card under '/sd' path in filesystem.
```

Should all be uncommented and look as above. This will configure the code to write GPS NMEA data to the **/sd/gps.txt** file, appending new data to the end of the file.

Once the example is running as a **main.py** on your board open the serial REPL and you should see the raw NMEA sentences printed out:

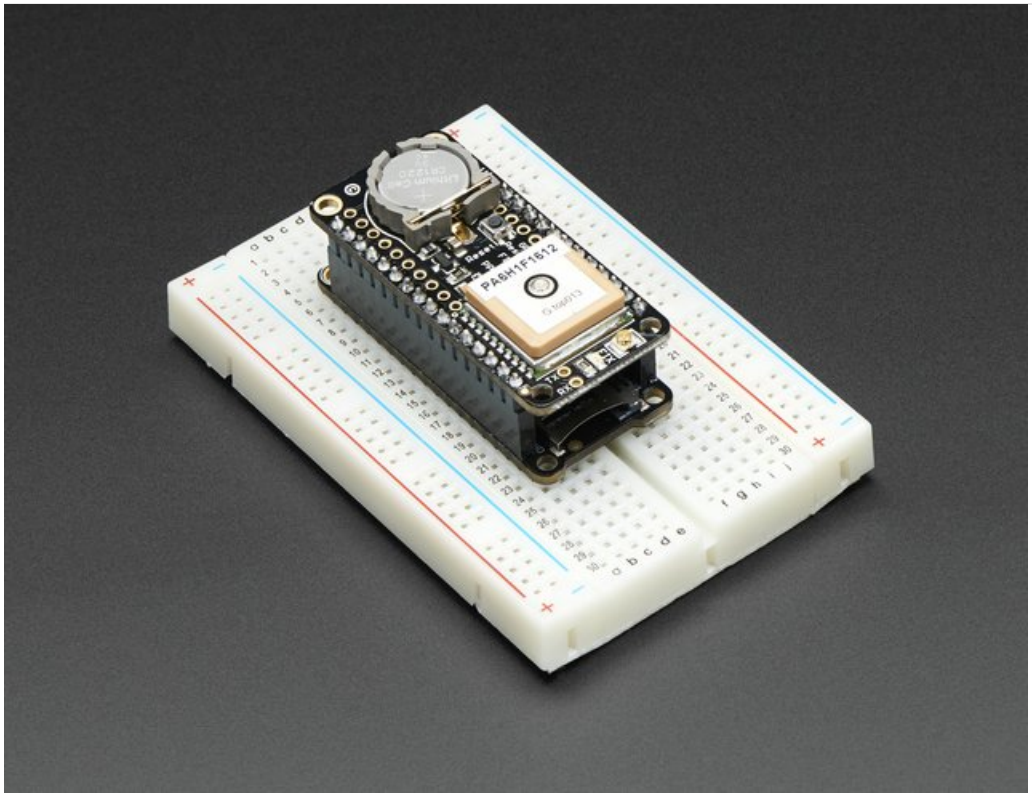


Check the **gps.txt** file (either under the root or /sd path depending on how you setup the example) in a text editor and you'll see the same raw NMEA sentences:



Awesome! That's all there is to basic datalogging of NMEA sentences with a GPS module and CircuitPython!

Battery Backup

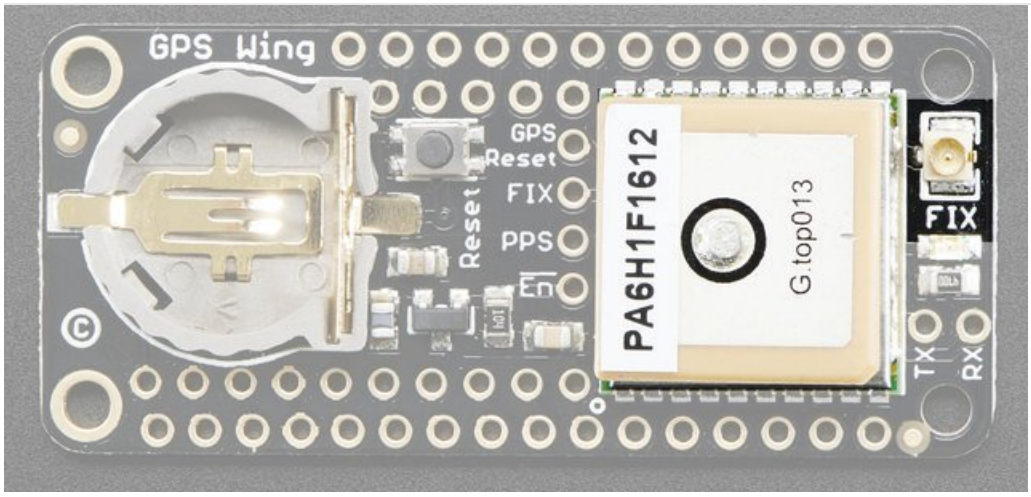


The GPS has a built in real time clock, which can keep track of time even when it power is lost and it doesn't have a fix yet. It can also help reduce fix times, if you expect to have a flakey power connection (say you're using solar or similar). To use the RTC, we need to install a battery. We provide the holder but the battery is not included. You can use any 12mm coin cell - these are popular and we also carry them in the Adafruit shop.

Normally, if the GPS loses power, it will revert to the factory default for baud rates, configuration, etc. A backup battery will mean that those defaults will not be lost!

The backup real-time-clock circuitry draws 7 uA (0.007 mA) so a CR1220 will last 40mAh / 0.007mA = 5,714 hours = 240 days continuously. The backup battery is only used when there's no main 3V power to the GPS, so as long as it's only used as backup once in a while, it will last years

Antenna Options



All Ultimate GPS modules have a built in patch antenna - this antenna provides -165 dBm sensitivity and is perfect for many projects. However, if you want to place your project in a box, it might not be possible to have the antenna pointing up, or it might be in a metal shield, or you may need more sensitivity. In these cases, you may want to use an external active antenna.

Active antennas draw current, so they do provide more gain but at a power cost. Check the antenna datasheet for exactly how much current they draw - its usually around 10-20mA.

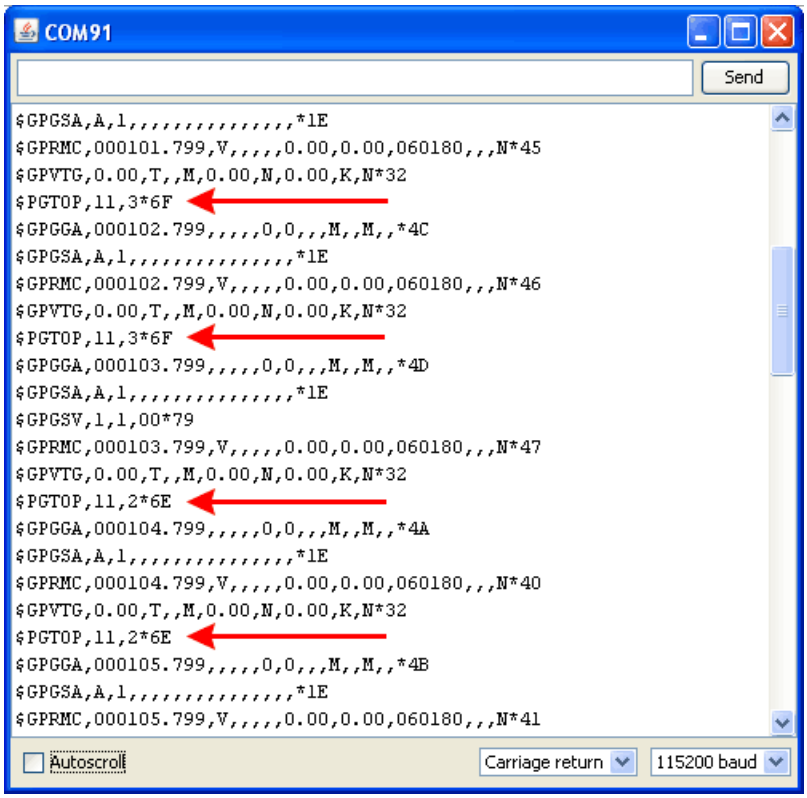
Most GPS antennas use SMA connectors, which are popular and easy to use. However, an SMA connector would be fairly big on the GPS breakout so we went with a uFL connector - which is lightweight, small and easy to manufacture. If you don't need an external antenna it wont add significant weight or space but its easy to attach a uFL->SMA adapter cable. Then connect the GPS antenna to the cable.

> uFL connectors are small, delicate and are not rated for strain or tons of connections/disconnections. Once you attach a uFL adapter use strain relief to avoid ripping off the uFL

The Ultimate GPS will automagically detect an external active antenna is attached and 'switch over' - you do not need to send any commands

There is an output sentence that will tell you the status of the antenna. **$PGTOP,11,x** where **x** is the status number. If **x** is **3** that means it is using the external antenna. If **x** is **2** it's using the internal antenna and if **x** is **1** there was an antenna short or problem.

On newer shields & modules, you'll need to tell the firmware you want to have this report output, you can do that by adding a **gps.sendCommand(PGCMD_ANTENNA)** around the same time you set the update rate/sentence output.


COM91
Send
$GPGSA,A,1,,,,,,,,,,,,,,*1E
$GPRMC,000101.799,V,,,,,0.00,0.00,060180,,,N*45
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32
$PGTOP,11,3*6F
$GPGGA,000102.799,,,,,0,0,,,M,,M,,*4C
$GPGSA,A,1,,,,,,,,,,,,,,*1E
$GPRMC,000102.799,V,,,,,0.00,0.00,060180,,,N*46
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32
$PGTOP,11,3*6F
$GPGGA,000103.799,,,,,0,0,,,M,,M,,*4D
$GPGSA,A,1,,,,,,,,,,,,,,*1E
$GPGSV,1,1,00*79
$GPRMC,000103.799,V,,,,,0.00,0.00,060180,,,N*47
$GPVTG,0.00,T,,M,0.00,N,0.00,K,N*32
$PGTOP,11,2*6E
$GPGGA,000104.799,,,,,0,0,,,M,,M,,*4A
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$PGTOP,11,2*6E
$GPGGA,000105.799,,,,,0,0,,,M,,M,,*4B
$GPGSA,A,1,,,,,,,,,,,,,,*1E
$GPRMC,000105.799,V,,,,,0.00,0.00,060180,,,N*41
Autoscroll
Carriage return
115200 baud

Resources

Datasheets

- MTK3329/MTK3339 command set sheet for changing the fix data rate, baud rate, sentence outputs, etc!
- PMTK 'complete' datasheet (like the above but with even more commands)
- Datasheet for the PA6B (MTK3329) GPS module itself
- Datasheet for the PA6C (MTK3339) GPS module itself
- Datasheet for the PA6H (MTK3339) GPS module itself
- MT3339 GPS PC Tool (windows only) and the PC Tool manual
- Sample code and spec sheet for the LOCUS built-in logger
- LOCUS (built-in-datalogging system) user guide
- Mini GPS tool (windows only)

More reading:

- Trimble's GPS tutorial
- Garmin's GPS tutorial

Adafruit GPS Library for Arduino

https://github.com/adafruit/Adafruit-GPS-Library/

EPO files for AGPS use

Data format for EPO files

MTK_EPO_Nov_12_2014.zip

https://adafru.it/eb1

F.A.Q.

Can the Ultimate GPS be used for High Altitude? How can I know?

Modules shipped in 2013+ (and many in the later half of 2012) have firmware that has been tested by simulation at the GPS factory at 40km.

You can tell what firmware you have by sending the firmware query command **$PMTK605*31** (you can use the echo demo to send custom sentences to your GPS)

If your module replies with **AXN_2.10_3339_2012072601 5223** that means you have version #5223 which is the 40Km-supported firmware version. If the number is higher then 5223 then its even more recent, and should include the 40Km support as well

HOWEVER these modules are not specifically designed for high-altitude balloon use. People have used them successfully but since we (at Adafruit) have not personally tested them for hi-alt use, we do not in any way guarantee they are suitable for high altitude use.

Please do not ask us to 'prove' that they are good for high altitude use, we do not have any way to do so

If you want to measure high altitude with a GPS, please find a module that can promise/guarantee high altitude functionality

OK I want the latest firmware!

Here is the binary of the 5632 firmware, you can use this tool to upload it using an FTDI or USB-TTL cable (or direct wiring with FTDI). We do not have a tutorial for updating the firmware, if you update the firmware and somehow brick the GPS, we do not offer replacements! Keep this in mind before performing the update process!

I've adapted the example code and my GPS NMEA sentences are all garbled and incomplete!

We use SoftwareSerial to read from the GPS, which is 'bitbang' UART support. It isn't super great on the Arduino and does work but adding too many delay()s and not calling the GPS data parser enough will cause it to choke on data.

If you are using Leonardo (or Micro/Flora/ATmega32u4) or Mega, consider using a HardwareSerial port instead of SoftwareSerial!

How come I can't get the GPS to output at 10Hz?

The default baud rate to the GPS is 9600 - this can only do RMC messages at 10Hz. If you want more data output, you can increase the GPS baud rate (to 57600 for example) or go with something like 2 or 5Hz. There is a trade off with more data you want the GPS to output, the GPS baud rate, Arduino buffer/processing capability and update rate!

Experimentation may be necessary to get the optimal results. We suggest RMC only for 10Hz since we've tested it.

How come I can't set the RTC with the Adafruit RTC library?

The real time clock in the GPS is NOT 'writable' or accessable otherwise from the Arduino. Its in the GPS only! Once the battery is installed, and the GPS gets its first data reception from satellites it will set the internal RTC. Then as long as the battery is installed, you can read the time from the GPS as normal. Even without a proper "gps fix" the time will be correct.

The timezone cannot be changed, so you'll have to calculate local time based on UTC!

Downloads

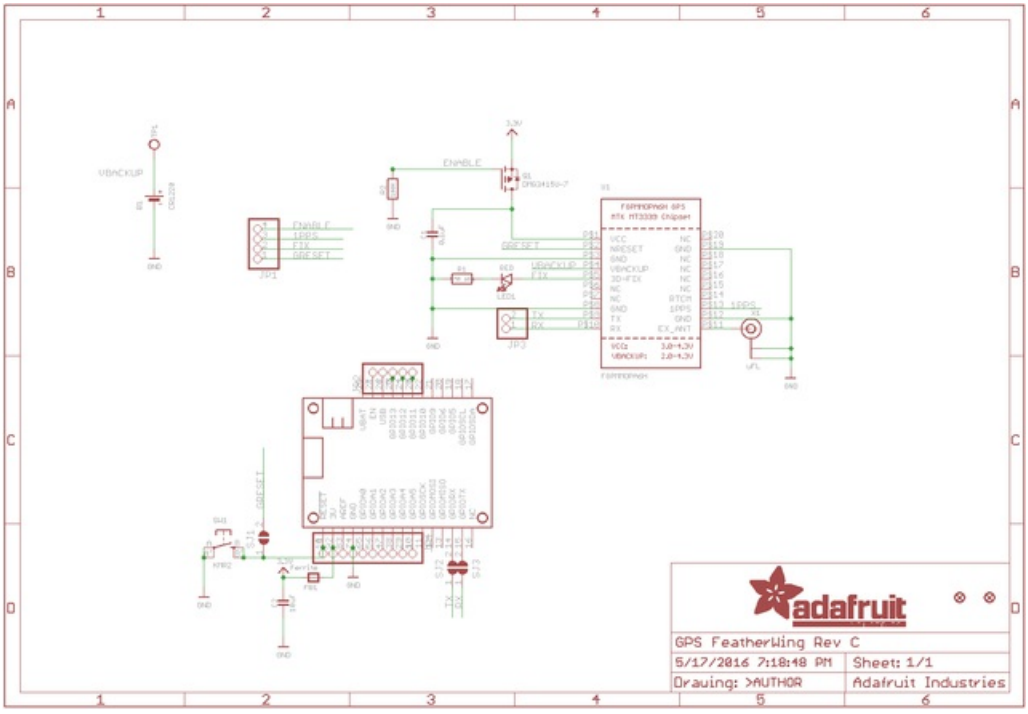
Datasheets & Files

- EagleCAD PCB Files on GitHub
- Fritzing object in Adafruit Fritzing library
- Adafruit GPS Arduino Library

- MTK3329/MTK3339 command set sheet for changing the fix data rate, baud rate, sentence outputs, etc!
- LOCUS (built-in-datalogging system) user guide
- Datasheet for the PA6H (MTK3339) GPS module itself
- MT3339 GPS PC Tool (windows only) and the PC Tool manual
- Mini GPS tool (windows only)

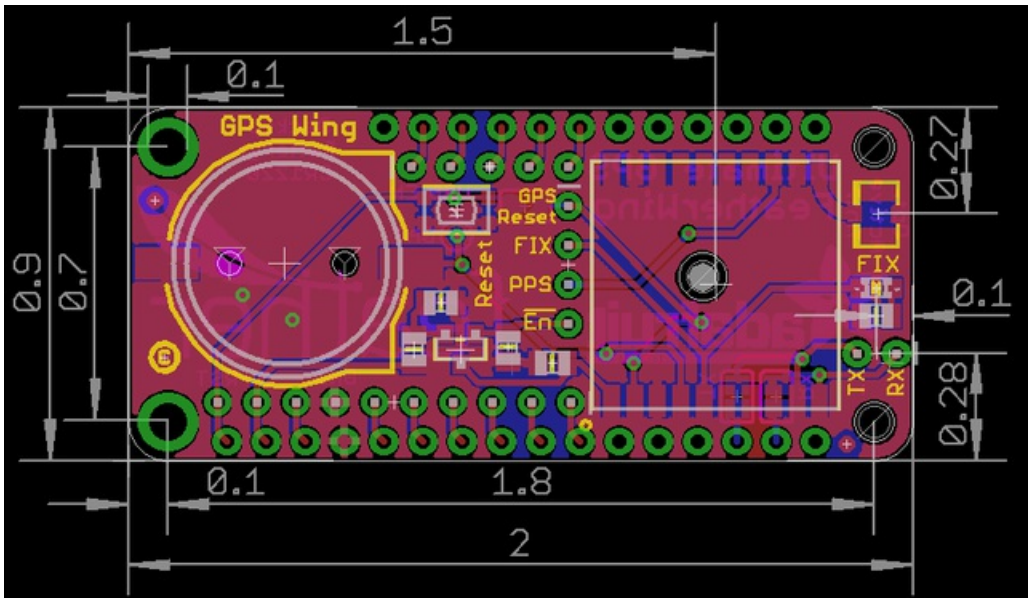
Schematic

Click to embiggen



Fabrication Print

Dimensions in inches


1.5
0.1
GPS Wing
GPS
Reset
FIX
PPS
En
Reset
FIX
TX
RX
0.27
0.1
0.28
0.9
0.7
0.1
1.8
2