CANSAT LUXEMBOURG

Hardware kit discovery

Presentation themes

- About the wiki @ cansat.mchobby.be
- Arduino Uno → Feather M0 Express
- Review the kit content
- Feather M0 Express and goodies
- LiPo batteries
- Radio transmission

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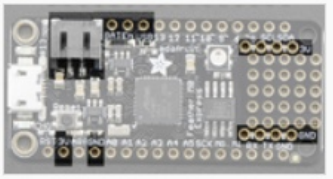
- Getting started guide

Hardware discovery



Discover the various items included within the kit.

Cliquez ici

Arduino IDE

Prepare your Arduino IDE environment

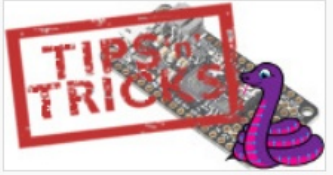
Cliquez ici

Feather User Guide

The **Feather M0 Express** user guide for Arduino IDE.

Cliquez ici

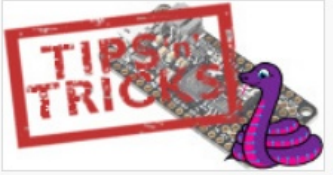
Forcing Flash Mode



Useful tip to know.

Cliquez ici

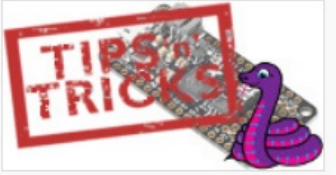
M0 Sketch tips



Tips and tricks to write sketch for the M0.

Cliquez ici

Using SPI Flash



Programing advice to work with integrated SPI Flash.

Cliquez ici

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- Getting started guide
- Testing the devices

BMP280 sensor

Test the BMP280 pressure and elevation sensor.

Cliquez ici

TMP36 sensor

Test the TMP36 analog temperature sensor

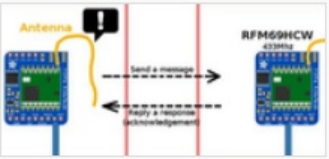
Cliquez ici

RFM69HCW radio

User guide for the **RFM69HCW** radio module.

Cliquez ici

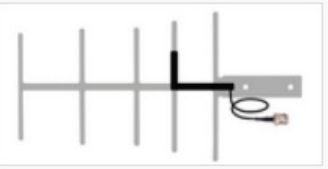
RFM69HCW Testing



Testing the communication with **RFM69HCW** and sending data through the radio module.

Cliquez ici

Radio Antenna



A well designed Antenna can increase the communication distance. Antenna and **alternative transmission devices**.

NeoPixel

Using the NeoPixel LED available on the board.

Cliquez ici

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- Getting started guide
- Testing the devices
- Mission 1
  Radio telemetry transmission.
  Capturing data.

Mission 1: Emitter

Wiring sensors, capturing datas and sending over radio.

Mission 1: Receiver

Receiving the transmitted data.

Cliquez ici

Mission 1: Going autonomous

Receiving the transmitted data.

Cliquez ici

/dev/ttyACM0 (Arduino/Genuino Uno)

```
[DATA](len=39,RSSI=-48):23182|37619675|25.84|97850.22|23.94;
[DATA](len=39,RSSI=-47):23183|37620079|25.52|97846.78|23.94;
[DATA](len=39,RSSI=-47):23184|37620483|25.84|97848.91|23.95;
[DATA](len=39,RSSI=-46):23185|37620886|25.84|97850.06|23.96;
[DATA](len=39,RSSI=-47):23186|37621290|25.52|97848.25|23.96;
[DATA](len=39,RSSI=-48):23187|37621693|25.84|97850.05|23.95;
[DATA](len=39,RSSI=-48):23188|37622097|25.84|97850.37|23.95;
[DATA](len=39,RSSI=-48):23189|37622501|26.16|97850.39|23.96;
[DATA](len=39,RSSI=-48):23190|37622904|25.84|97851.85|23.95;
[DATA](len=39,RSSI=-48):23191|37623308|25.84|97852.17|23.95;
[DATA](len=39,RSSI=-48):23192|37623712|25.84|97849.89|23.94;
[DATA](len=39,RSSI=-47):23193|37624115|25.84|97851.19|23.95;
[DATA](len=39,RSSI=-47):23194|37624519|26.16|97849.06|23.95;
[DATA](len=39,RSSI=-47):23195|37624922|26.16|97851.52|23.95;
[DATA](len=39,RSSI=-47):23196|37625326|25.84|97851.87|23.96;
[DATA](len=39,RSSI=-47):23197|37625730|25.84|97851.70|23.96;
```

Défilement automatique Les deux, NL et C

7 Capturing data to file
- 7.1 Putty
- 7.2 Linux command
- 7.3 With Python
- 7.4 Other options

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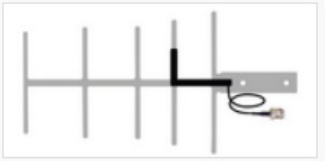
- Getting started guide
- Testing the devices
- Mission 1
  Radio telemetry transmission.
  Capturing data.
- Resources

CanSat 3D

CanSat 3D models to print your own one

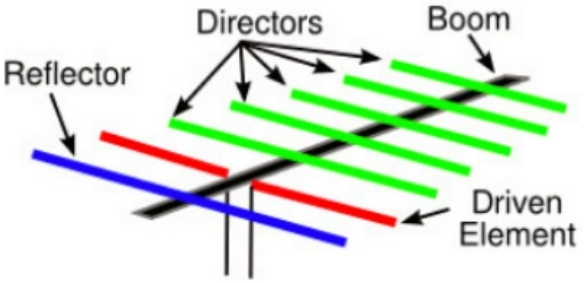
Cliquez ici

Radio Antenna



A well designed Antenna can increase the communication distance.

Cliquez ici



Parachute

Some reference to design the parachute

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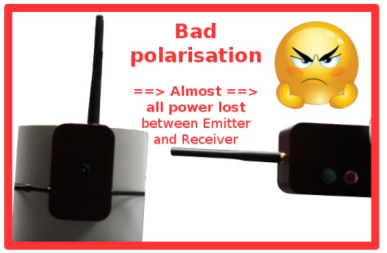
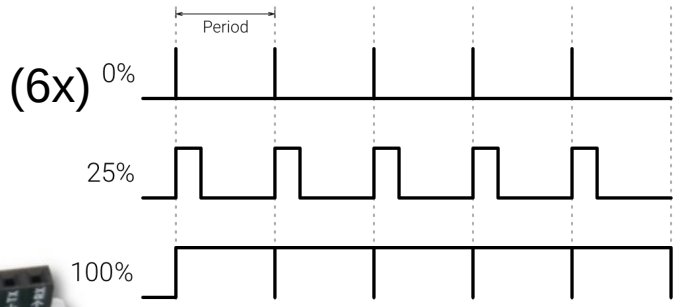
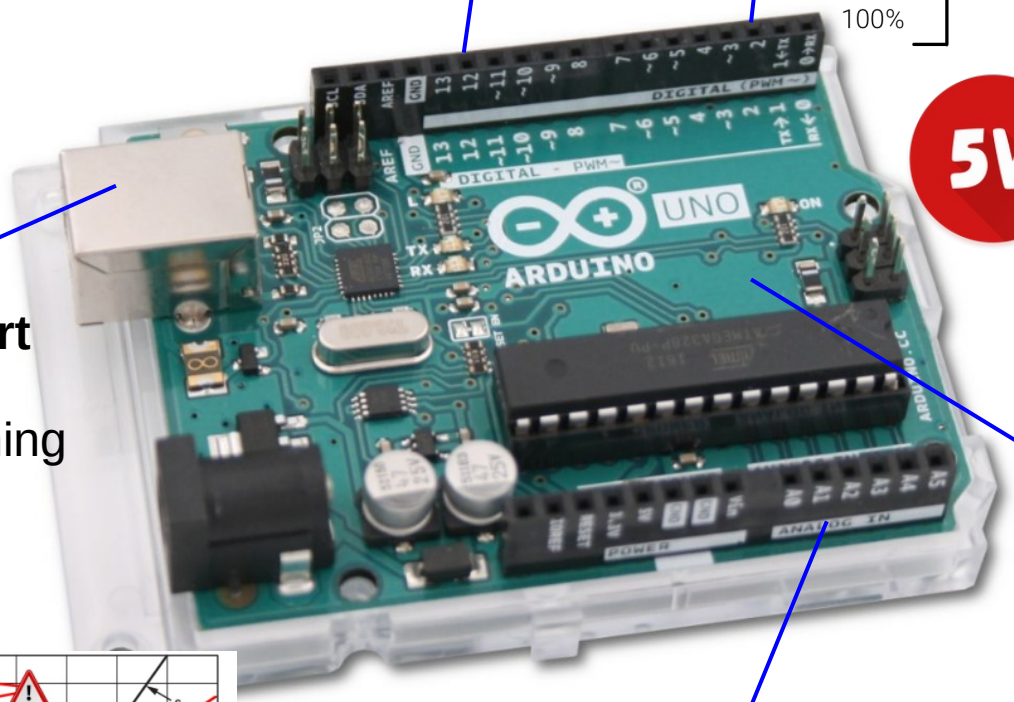


Arduino Uno → Feather M0



Digital I/O (13x)

Arduino UNO



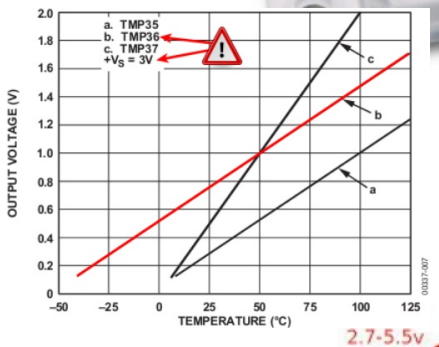
5V

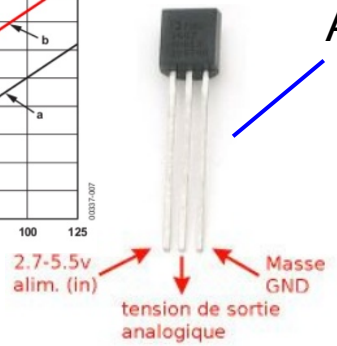
- Microcontroler ATmega328
- 32K Flash
- **2K SRam** 2048 char.

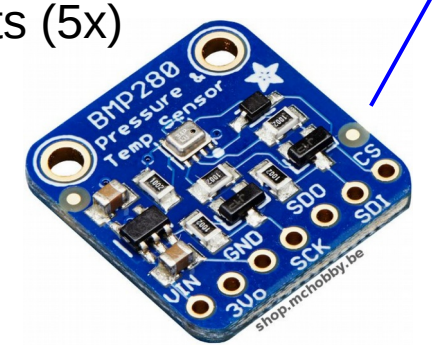
USB Port
easy
programming

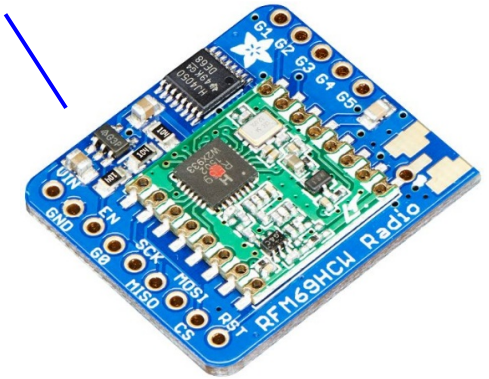
SPI & I2C buses
Easy connection
for sensors and
circuitery

Analog inputs (5x)



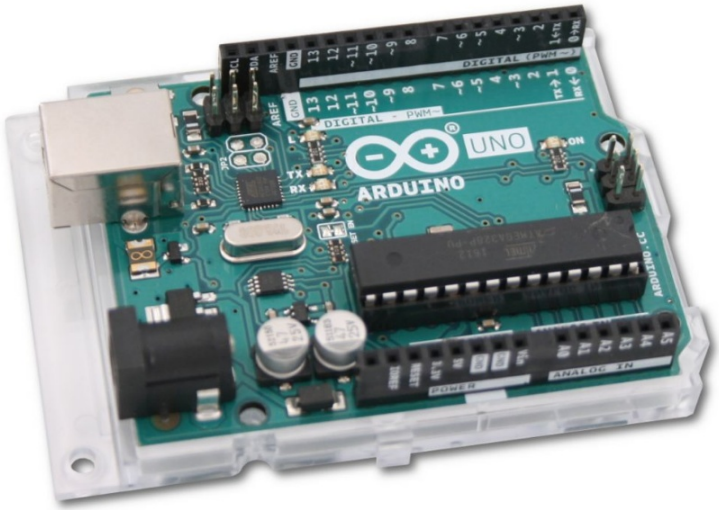


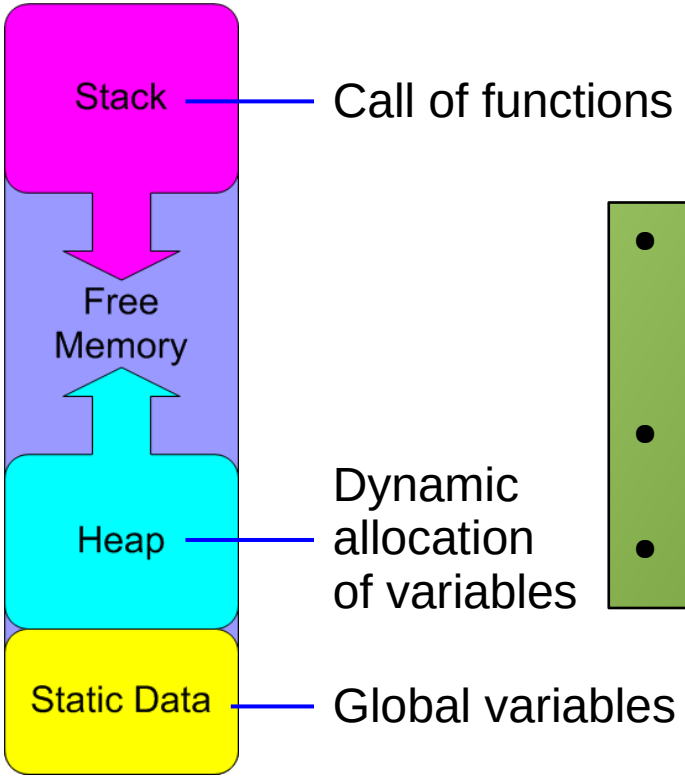




Arduino Uno → Feather M0

Arduino UNO





- Microcontroler ATmega328
- 32K Flash
- **2K SRam** 2048 char.

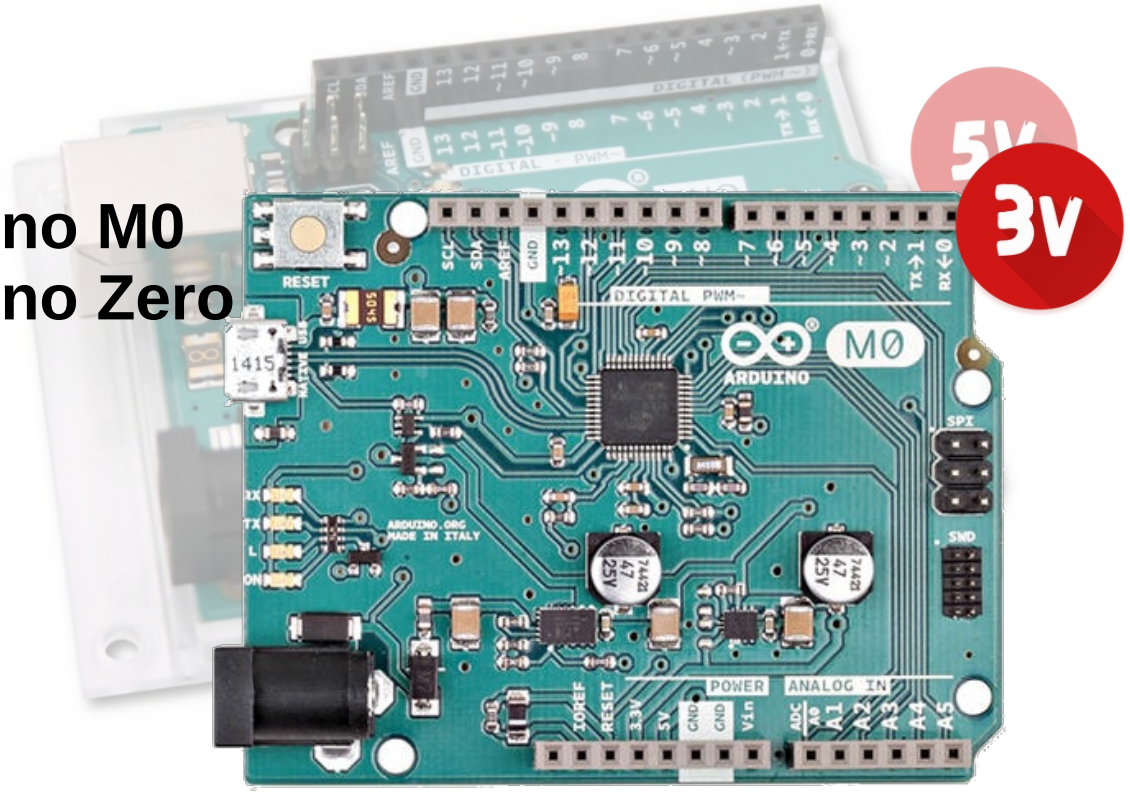
```
Sketch uses 21,316 bytes (66%) of program storage space. Maximum
is 32,256 bytes.
Global variables use 1,629 bytes (79%) of dynamic memory, leaving
419 bytes for local variables. Maximum is 2,048 bytes.
Low memory available, stability problems may occur.
```

Arduino Uno → Feather M0

~~Arduino UNO~~

- Microcontroler ATmega328
- 32K Flash
- **2K SRam** 2048 char.

Arduino M0
Arduino Zero



- Microcontroler ATSAMD21G18 (ARM Cortex M0+)
- 256K Flash
- **32K SRam** 32768 char.

M0

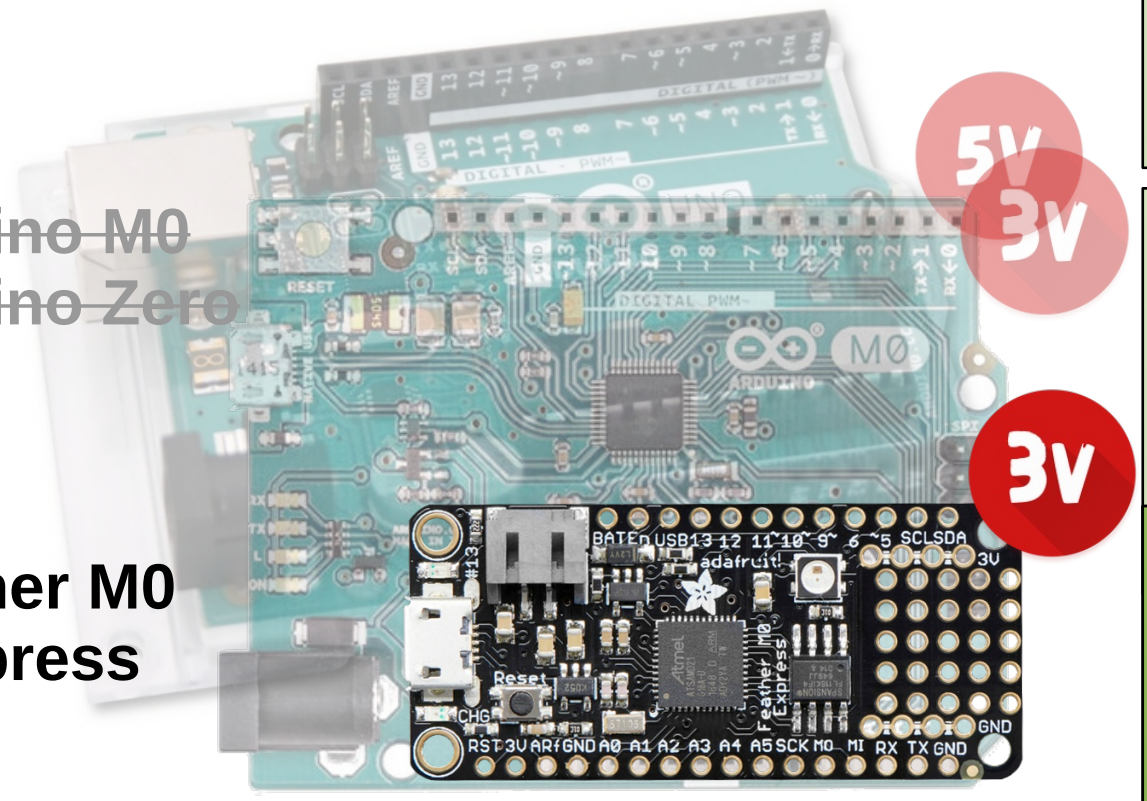
6x analog input
1x **analog output**
16 Mhz → **48 Mhz**

Arduino Uno → Feather M0

~~Arduino UNO~~

~~Arduino M0~~
~~Arduino Zero~~

Feather M0 Express



- Microcontroler ATmega328
- 32K Flash
- **2K SRam** 2048 char.

- Microcontroler ATSAMD21G18 (ARM Cortex M0+)
- 256K Flash

- Microcontroler ATSAMD21 (ARM Cortex M0+)
- 256K Flash
- **32K SRam** 32768 char.

Feather

1x Lipo charger
1x **SPI Flash**
1x NeoPixel LED

Arduino Uno → Feather M0

Feather M0 Express

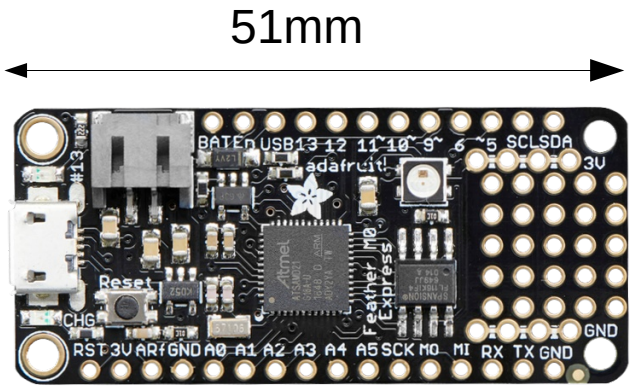
Feathers are :

- Small (5 x 2cm)
- Light (4,7 gr)
- Powerful
- Versatile
- Polyvalent
- Provided with complete ecosystem

shop.mchobby.be/87-feather

Feather M0 features :

- 20 GPIOs
- 6 Analog inputs - 12 bits
- 1 Analog output - 10 bits
- PWM outputs on all pins
- Hardware I2C, SPI buses
- UART



4.7 Gr

- Microcontroler ATSAMD21 (ARM Cortex M0+)
- 48 MHz
- 256K Flash
- **32K SRam** 32768 char.

3V

ARDUINO M0 compatible
store.arduino.cc/arduino-m0

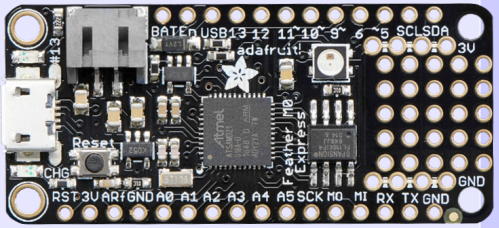
circuit python
MicroPython for electronic prototyping
learn.adafruit.com/welcome-to-circuitpython

Feather

1x Lipo charger
1x **SPI Flash**
1x NeoPixel

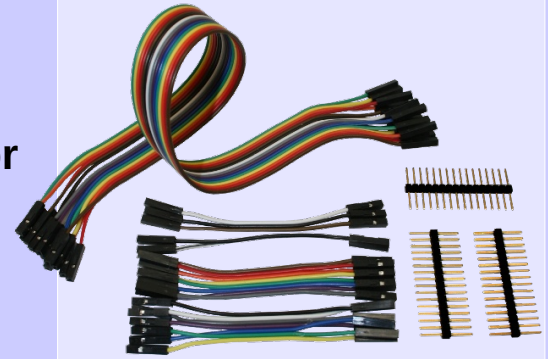
CanSat kit content

CanSat kit content



Feather M0 Express New Arduino M0 compatible on a **standard platform for embedded project**.

Compatible with Arduino IDE and CircuitPython



Multi-functional breadboard wires

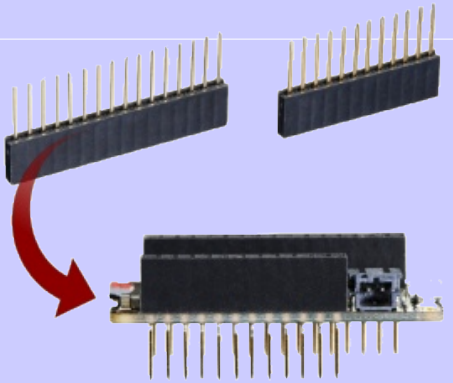
Set of wires with plug that can be modified from female to male.

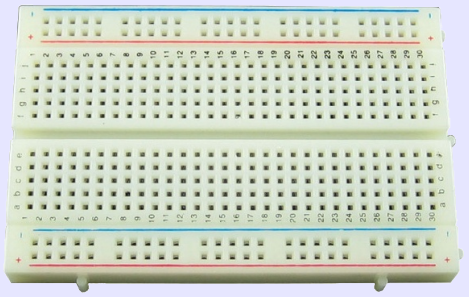
USB A/microB 1m cable.

Used to plug your feather on a computer to program it or to recharge the battery.

Feather Stacking Headers

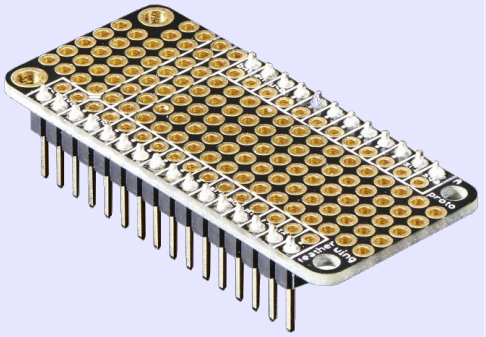
Plug your feather or prototype wing on breadboard and still having a female con-nector under the hand.





Half Size Breadboard

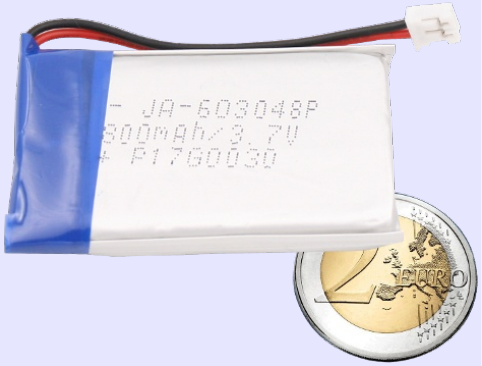
Solderless breadboard are used for fast prototyping.



Feather Prototyping Wing

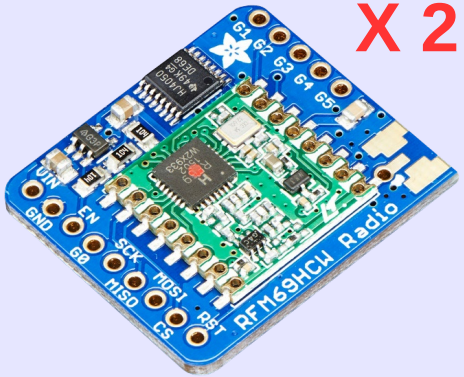
Prototyping board for Feather platform. Create your own extension board.

CanSat kit content



Lithium Polymer Battery

Transform the Feather into an autonomous plateform with this 800mAh Lipo.

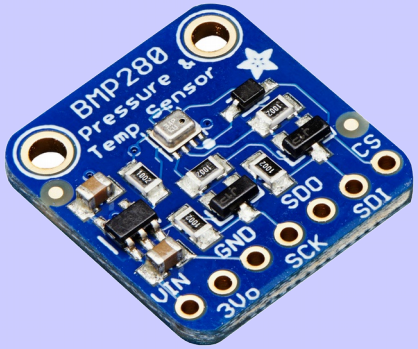


RFM69HCW Transceiver Radio

Transport data over long distance with packet radio. One breakout act as emitter, the second one as receiver.

BMP280 Barometric pressure sensor

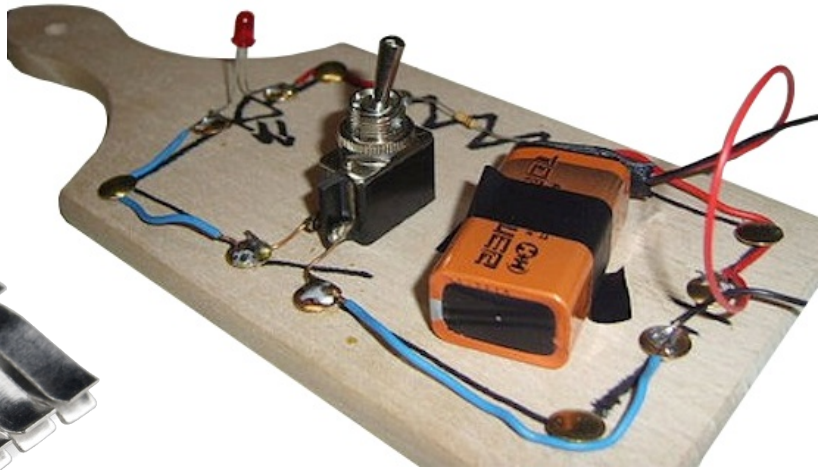
Easily evaluate pressure, altitude and temperature.

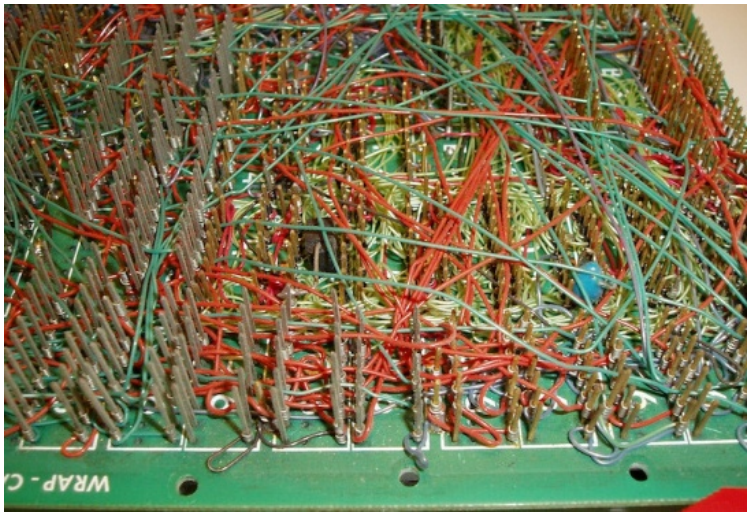


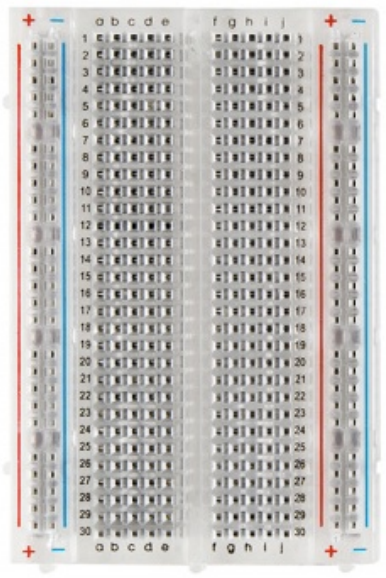
TMP36 – analog temperature sensor

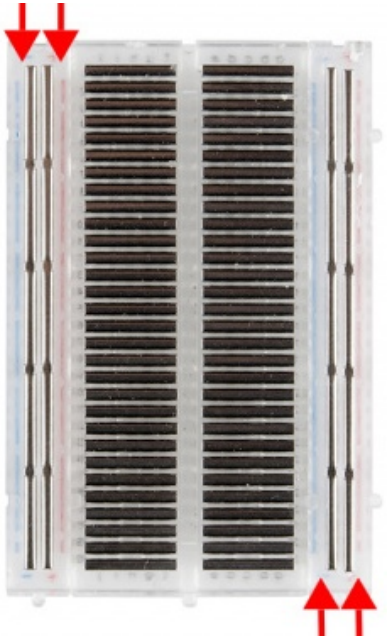
Transform the sensor voltage read to an easy-to-read temperature.

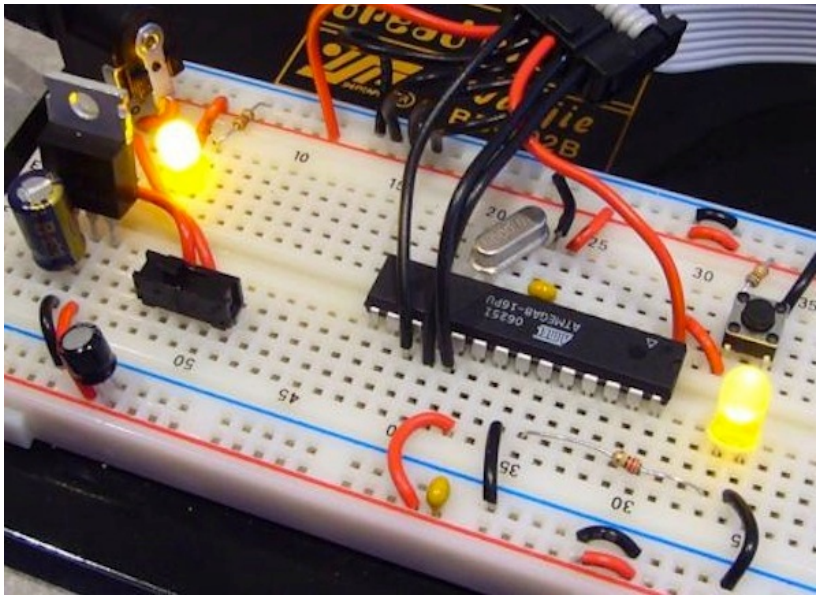
CanSat kit content - breadboard





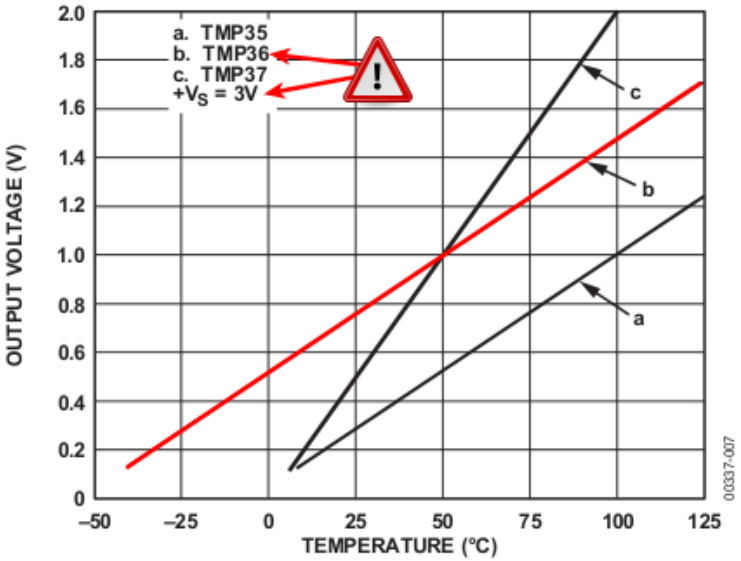






CanSat kit content - TMP36

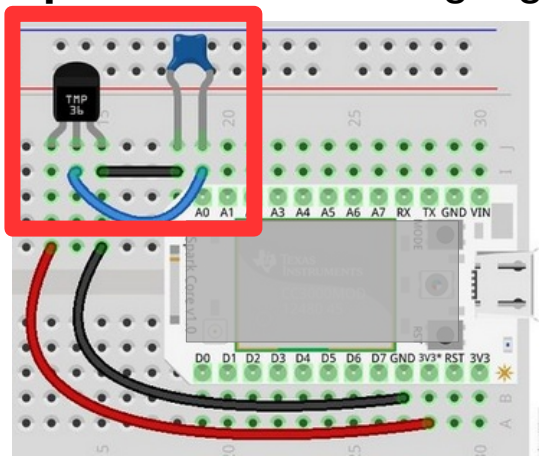
0V to 1.75V
-50°C to 125°C



Here is the formula to use with a TMP36 powered at 3.3v:

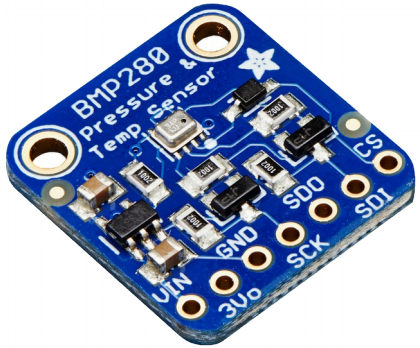
```
Temp in °C = ( output_voltage_in_mV - 500) / 10
```

Tip & Trick – Filtering signal for greater stability



Depending on the other device you may add to your experiment, some electrical parasite may be rejected on the power supply stage.
In such case, you will notice inconsistencies when reading analog devices.
Adding a 0.01µF (10nF) ceramic capacity between ground and the microcontroler analog input can filter those parasites (seen as high frequency spikes).

CanSat kit content - BMP280

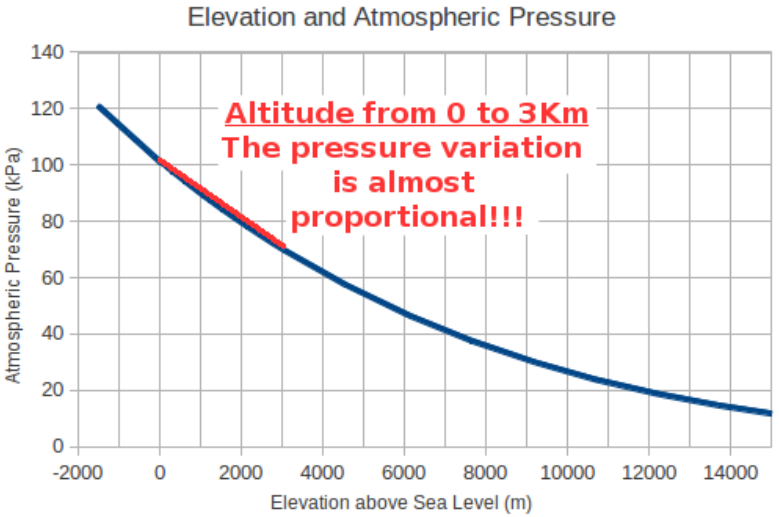


- Can use **I2C** or SPI bus
- Accuracy ± 1 hPa
  (= 100 Pa = 1 millibar)
- Pressure range:
  300...1100 hPa
- Temperature range:
  -40…85°C

Tip & Trick – Measure the altitude

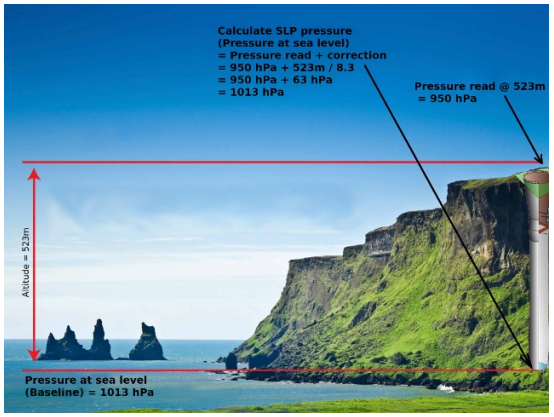
As the pressure also change with the altitude, whenever the **pressure decrease from 1hPa the altitude increase of 8.3 meter**s.

The pressure sensor accuracy allows you to use the BMP280 to make an altimeter (accuracy of ±1m at worste, about 0.25m in best conditions)



Interesting Learning – Measure your absolute altitude

By using the today's pressure at sea-level, it is possible to calculate the absolute altitude of school / house. Compare it to one of the reference weather station near of your location.

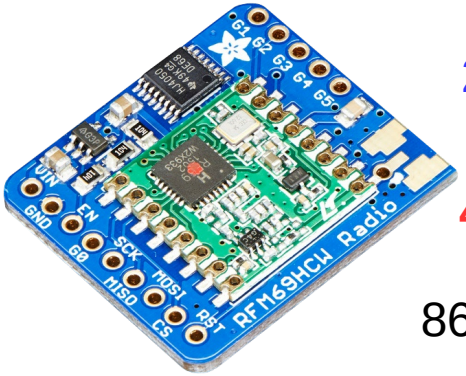


Interesting Learning – Calculate SLP (Sea Pressure Level)

Normalising your local pressure at the Sea Level (like reference wheater station does), you can compare your data with other reference station to make more accurate weather forecast.

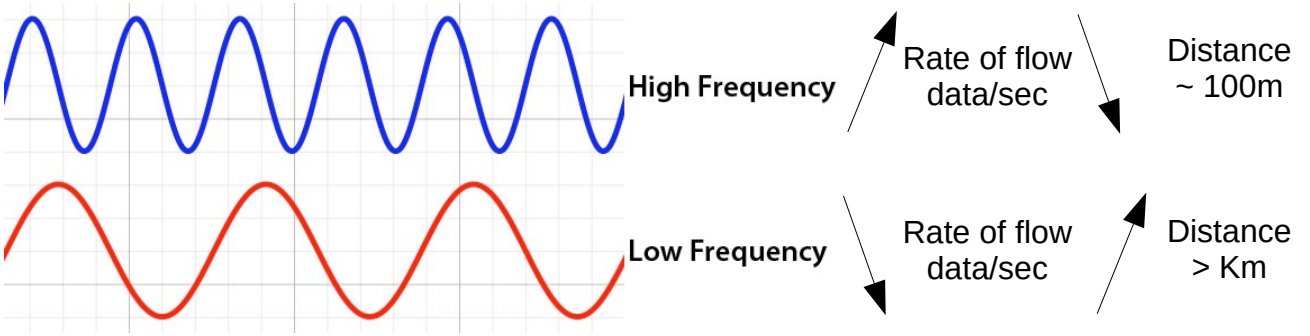
This is explained in wiki page related to BMP280 with detailed calculation.
See the picture with the well !

CanSat kit content - RFM69HCW

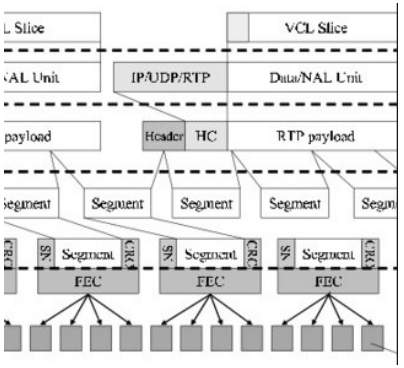


WiFi
2.4Ghz

Radio
433Mhz
LoRa
869.45 Mhz



- Use the SPI bus
- Around 433 Mhz
- 50mA @ +13 dBm
  150mA @ +20 dBm
- Distance :
  500m to 2 Km (5 Km).



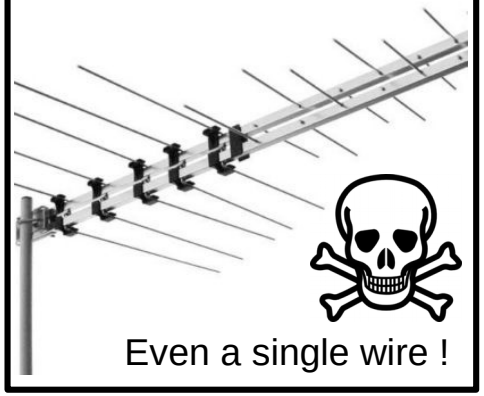
RFM69HCW - Packet Radio

This means that the module takes care of data coding, transmission, checksum, send retries, etc over the radio waves.

RFM69HCW – Frequency and encryption key

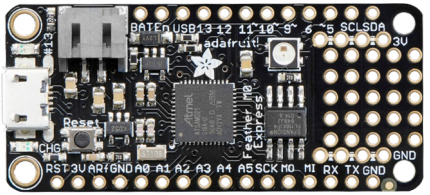
The RFM69HCW frequency can be adjuted (around 433Mhz) and data is AES encrypted with a key. Both are defined in the software and are the only parameters you really have to take care about.

Antenna required !

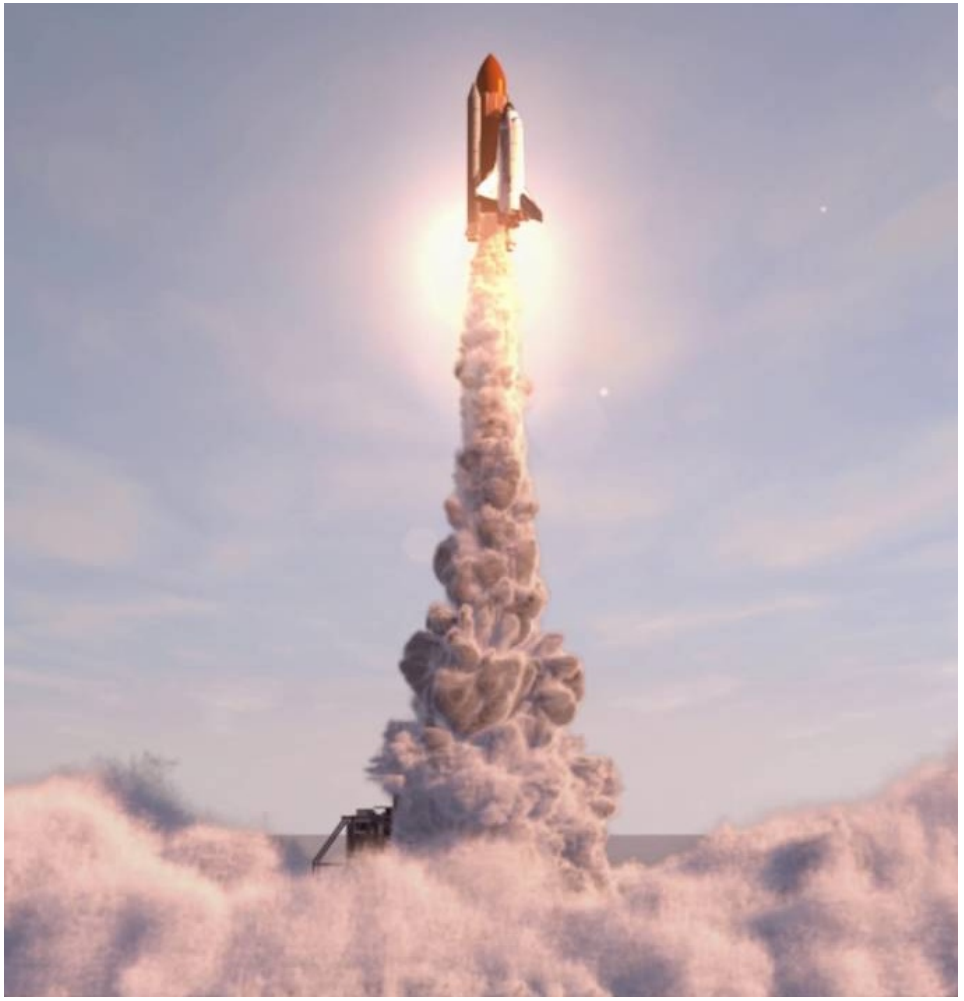


Even a single wire !

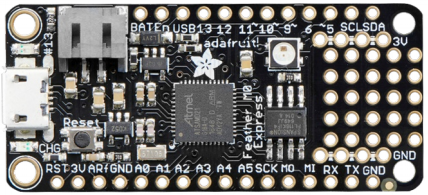
The Sender and Receiver module must have :
The same frequency and
The same encryption key.



Feather M0 Express



A bunch of power and goodies
to launch your project



Feather M0 Express

3V

400mA max

Lipo Battery (Charge rate @ 100mA)
JST connector to power
from Lipo or to recharge it.

User LED
wired on pin #13

microUSB
- Program with Arduino IDE
- Store Python Script
- Recharge LiPo

Microcontroler
ATSAMD21 Cortex M0
(identical to Arduino Zero)

7,3mm

Charging LED
State of the Lipo Charger.

NeoPixel LED
Autonomous digital RGB LED

Prototyping area

RTC
Real Time Clock
Crystal at 32.768 KHz

EXTRA FLASH (2Mb)
like a **microSD card**, this additional storage can be used to store data, files and python scripts.

5,1cm

2,28cm

6 Analog inputs
12 bits resolution.
Value 0 – 4096

Note :
Arduino IDE use 10 bit resolution by default (0 – 1024) but this could be changed with analogReadResolution(12)

1 Analog ouput
10 bits resolution.
Value 0 – 1024

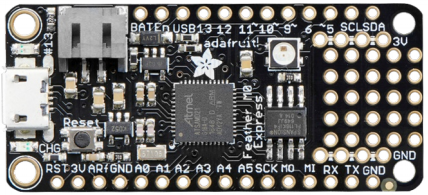
Serial still available !

Feather M0 Power vs *Arduino Uno*
Clock : **48 MHz** vs *16 MHz for Uno*
RAM : **32 Kb** vs *2Kb for Uno*
Flash : **256 Kb** vs *32Kb for Uno*
Real Time Clock : **Yes** vs *none for Uno*

Info ▶ TUTORIAL ▶

ENG: **cansat.mchobby.be#Getting_Started**
ENG: www.adafruit.com/product/3403
FR : shop.mchobby.be/product.php?id_product=1119

20 Pins (PWMable)
17mA / pin.
130MA max on chip

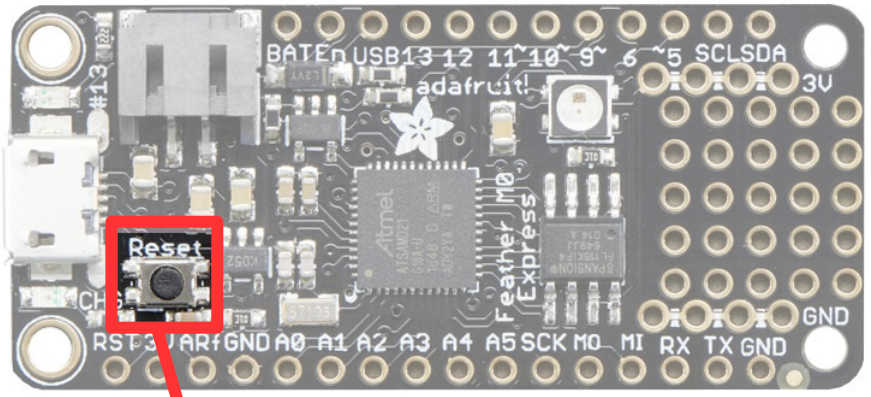


Feather M0 Express

Forcing bootloader

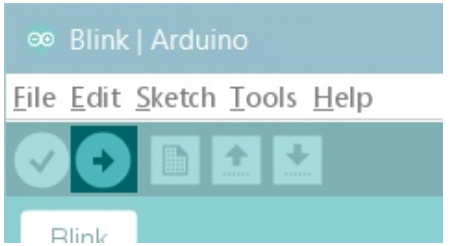
Sometime, it happens that compilation phase get complete successfully but the binary can't get uploaded to the board.

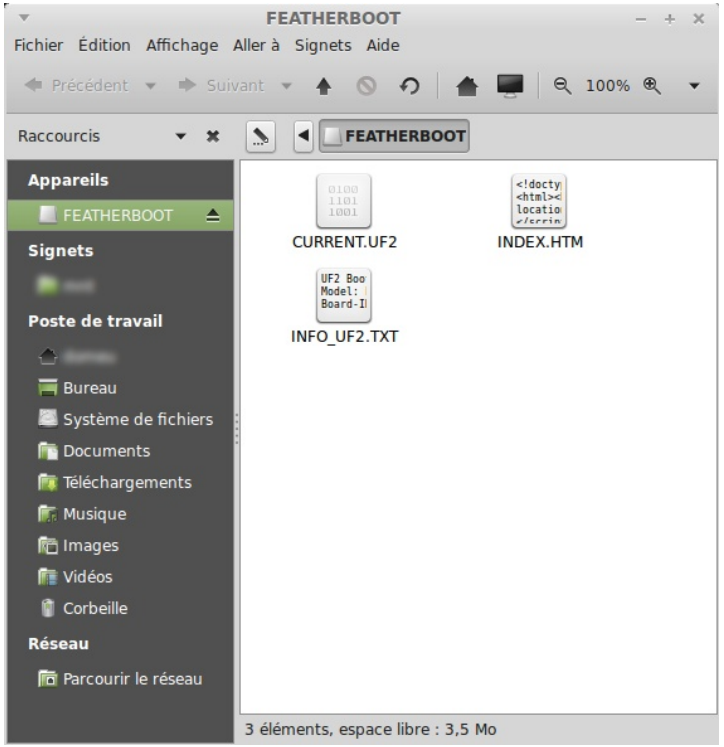
It is time for **Manual activation of the bootloader**

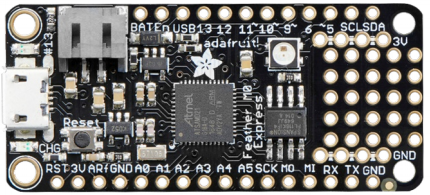


Press twice the reset button

Then, **press the upload button** in Arduino IDE
This time the new UF2 file will be uploaded successfully.







Feather M0 Express

Serial Monitor

The Feather M0 use the native USB support of ATSAMD21 chipset (Serial is in fact SerialUSB).

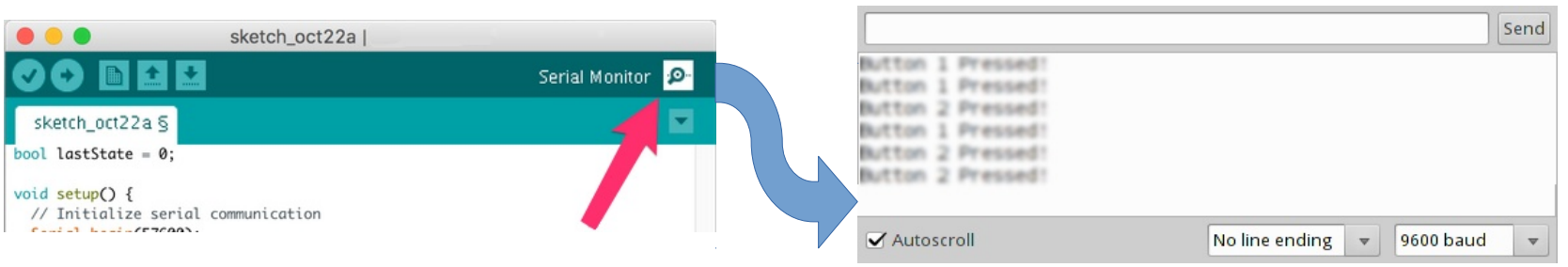
To wait for serial connexion (serial debug) at startup :

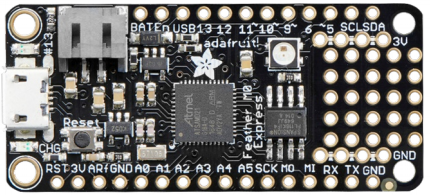
Add the following line in the begining of your sketch to wait for USB serial connection.

```
void setup() {
  Serial.begin(9600);

  // wait until serial console is open
  while (!Serial) { delay(1); }

  ….
}
```

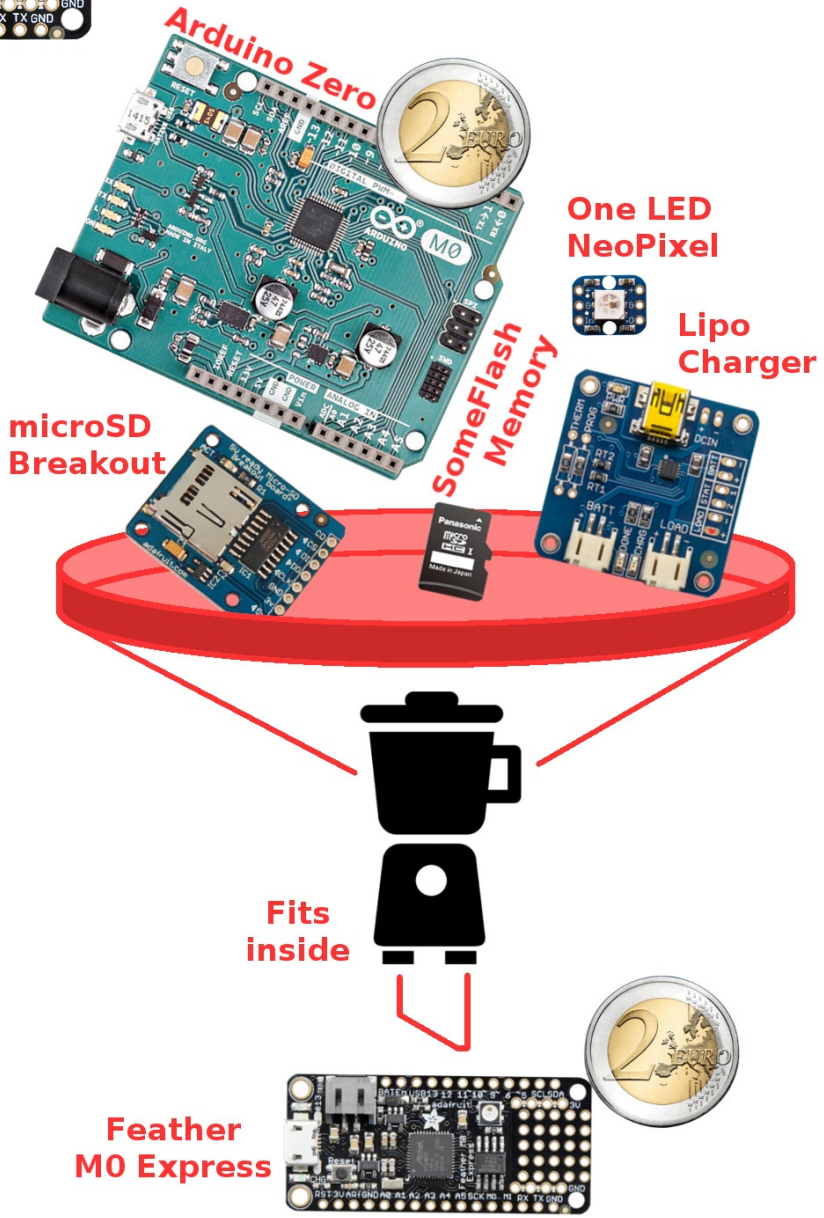
The `setup()` function would wait for « Serial Monitor » to effectively starts the sketch.

Then, **press the Serial Monitor button** in Arduino IDE





Feather M0 Express



This is the reason why the « Feather » becomes the

new standard for microcontroller embeded projects.

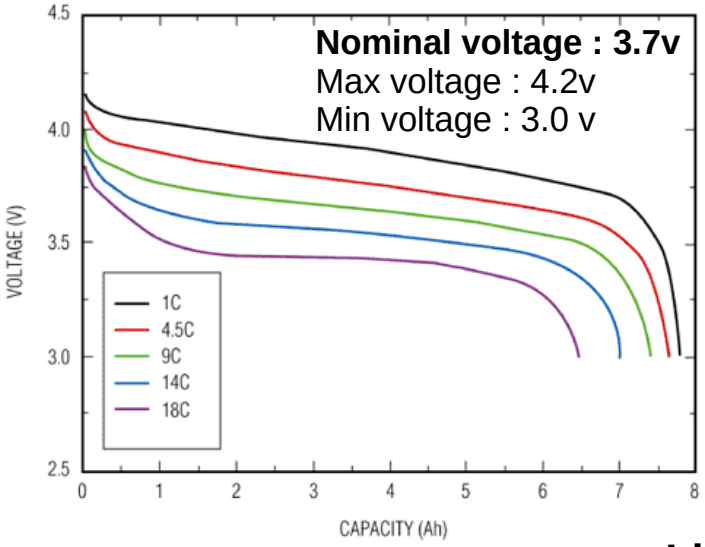
LiPo batteries

LiPo offers the best ratio Power/Weight.

Q (mAh) is the quantity of power.

C is discharge rate.
Charging is usually limited to half of discharge rate.

For battery with Q = 800mAh :
- 1C means that it can be discharged continuously at 800mA.
- 1/2C means that it can be discharged at 400mA.
- 3C means that it can be discharged at 2400mA.



Lipo for electronic
- Usually rated for 1C max.
- Use protection circuitry (over-current or under-voltage).
- Finer wires.
- Lighter.
- Power cycle the Lipo when security get activated.

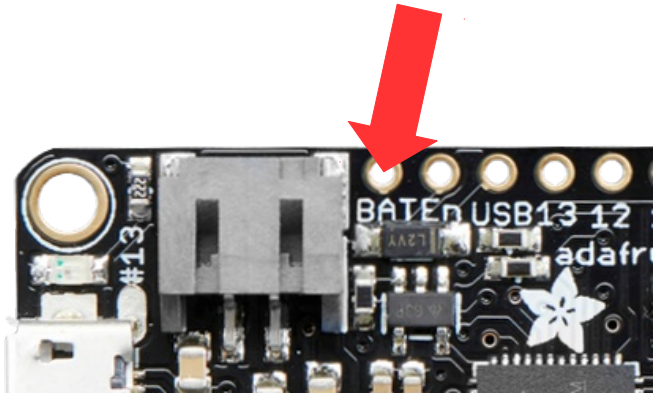
Lipo for portable radio and electric vehicles.
- Can deliver several C (40C or more).
- No protection circuitry.
- Thick wires.
- More heavy (more cells).
- Must be charged with special device & under surveillance.

LiPo batteries

Estimate discharge time :
If your project sink a current of 150mA then a 800 mAh Lipo will last after
800 mAh / 150 mA = 5.3 Hours

Getting higher voltage :

Direct acces to the battery.



LiPo can be used with step-up regulator to creates higher voltage for peripherals.

Reg. **S7V7F5**

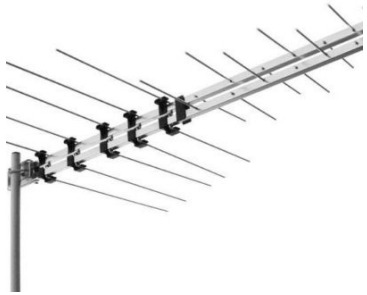
2.7 ... 11.8V => 5V 500mA

How it works :
Step-Up regulator pump current at the input to create higher voltage at the output.

So care about max current available at LiPo.

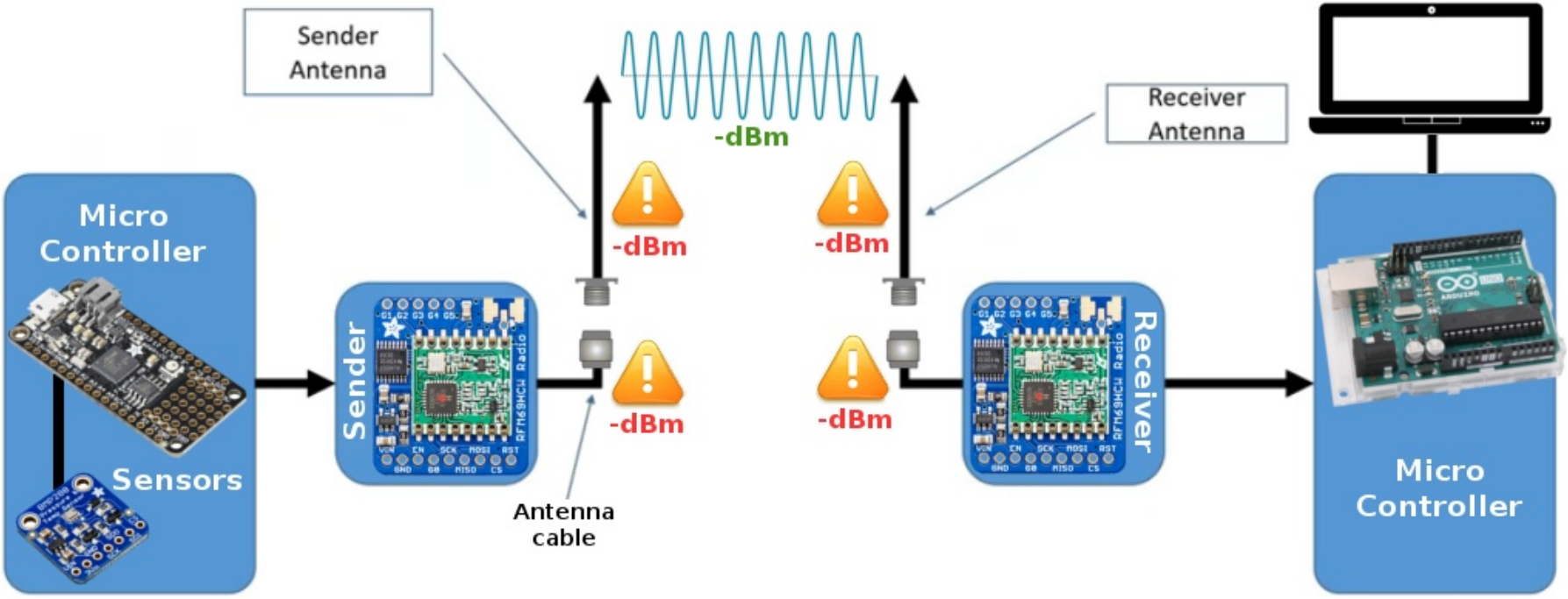
Do not abuse LiPo :

- Do not twist, bend.
- Do not drill.
- Do not fire.
- Do not over-charge/ over-discharge.
- Do not use when deformed or inflated.
- ALWAYS CHARGE UNDER SURVEILLANCE

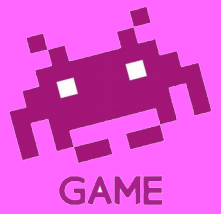


About Radio

The antenna is the key

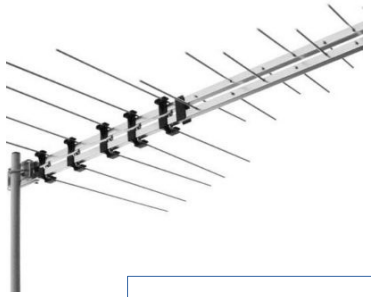


dBm = dB / measured mW = efficient way to measure absolute power.



Radio Transmission is a game where the goal is to lose as little power as possible !

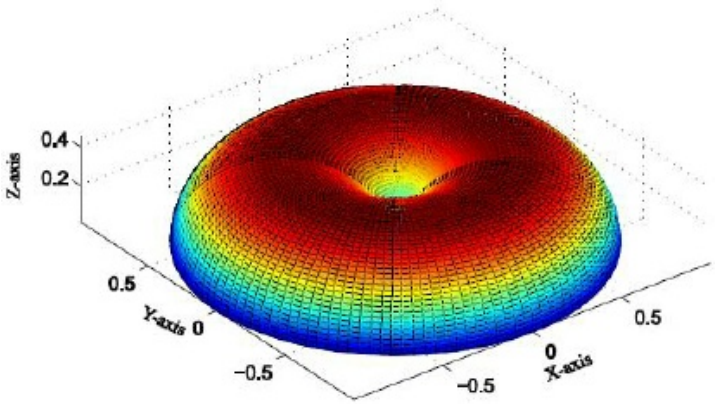
It is even possible to win power.



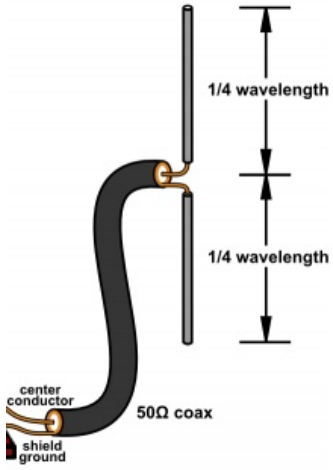
About Radio

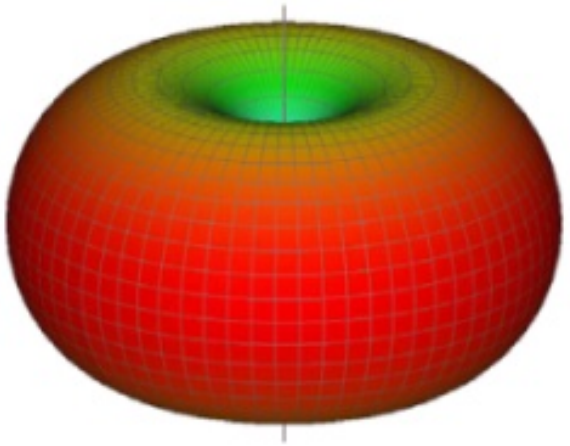
The antenna is the key

Unipole Antenna

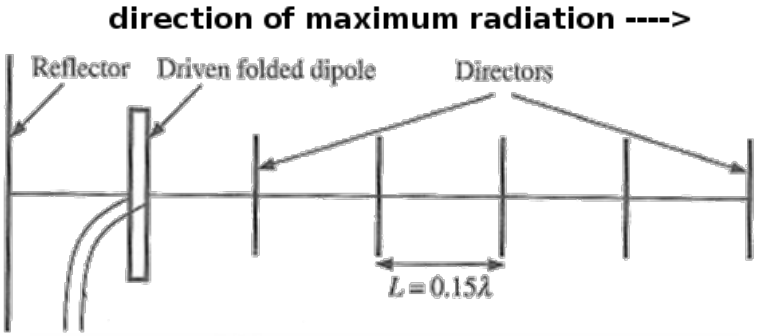


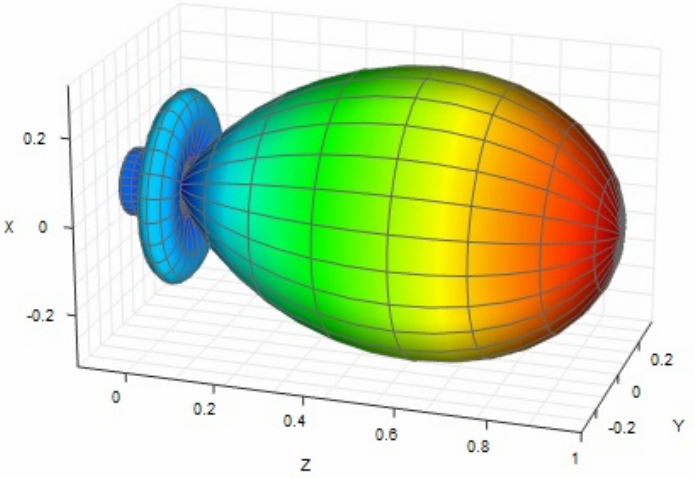
Dipole Antenna





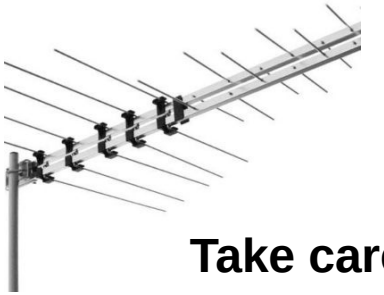
Yagi Antenna





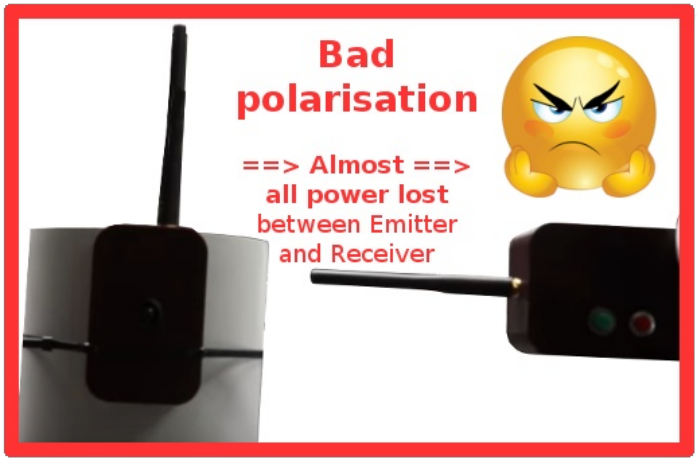
A 6 elements Yagi can offer a gain up to 11.2 dBi.
A 11 elements Yagi can double that gain !!!

See the wiki for a Yagi Antenna with build dimensions for 433Mhz antenna.



About Radio

Take care about the polarisation



Take care about antenna length

The frequency that the antenna resonates at (operates at) is determined by the length of the antenna.

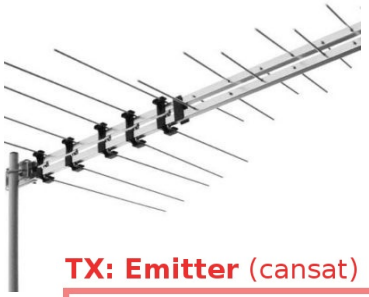
For unipole (and dipole) antenna, the maximum gain of the antenna is fixed and dependent on the operating frequency (the frequency the antenna should resonnate).

Quarter wavelength (1/4 λ) antenna length

$$L = \frac{c}{4 \times f}$$

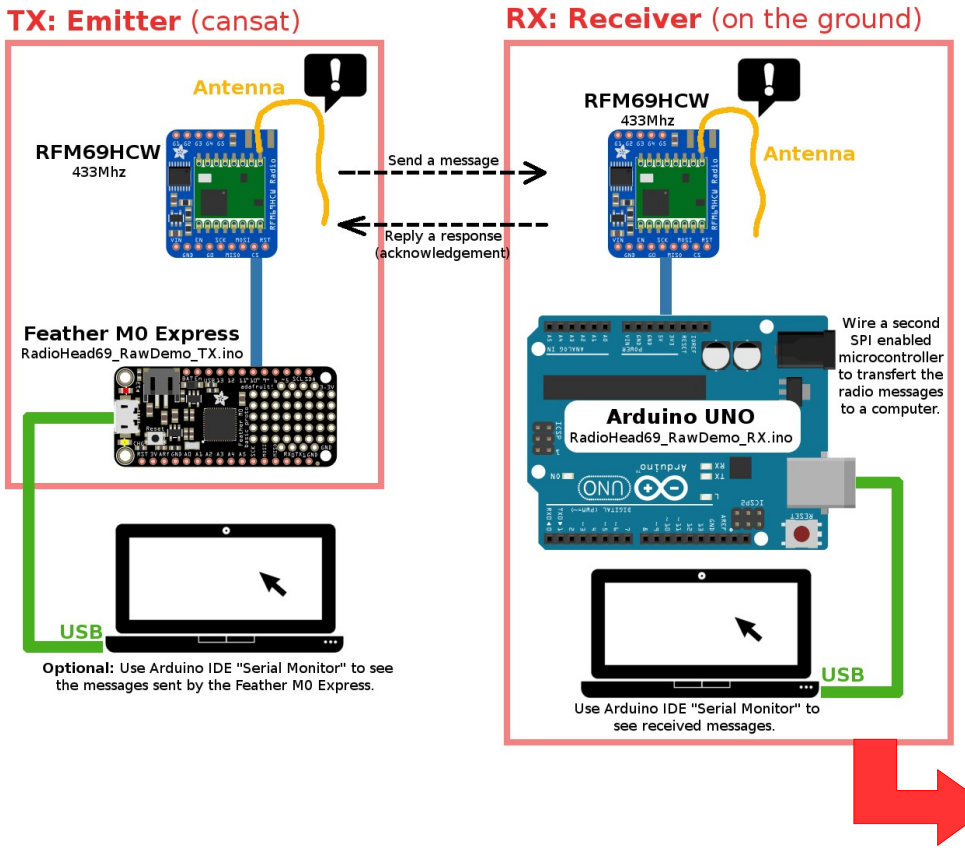
What should be the length of 1/4 λ antenna for the frequency of 433Mhz ?

$$L = \frac{3x10E8}{4 \times 433*10E6} = 0.1732m$$

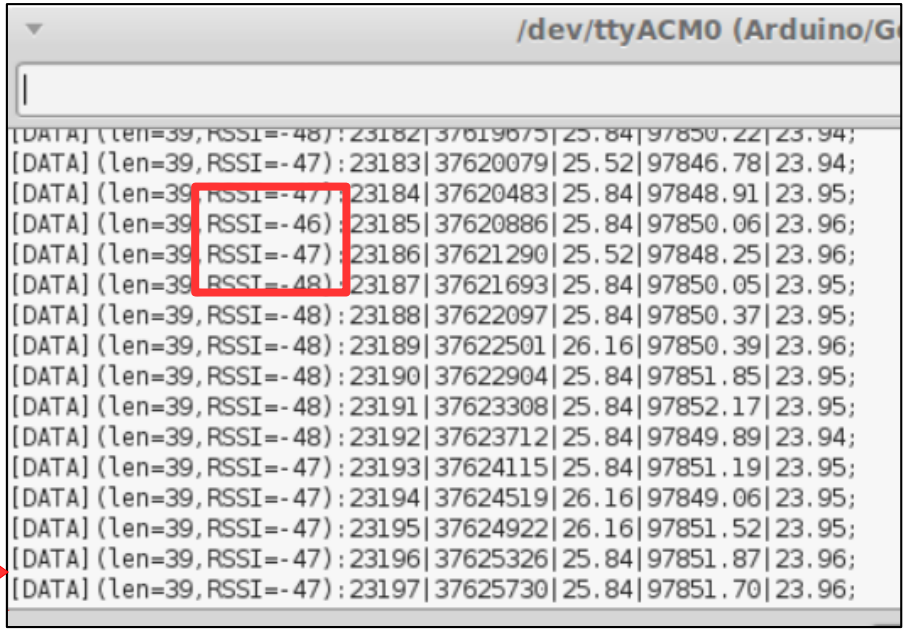


About Radio

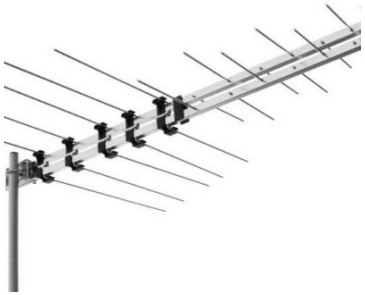
RSSI : Evaluate quality of radio setup !



When testing the « Mission 1 » setup available on the wiki, the receiver display the telemetric data with an additional information named RSSI.



RSSI: Received Signal Strength Indication - indicated the strength of the radio signal received on the transceiver. (-15 at best, -90 at worst).



About Radio

Getting Help with radio stuff !

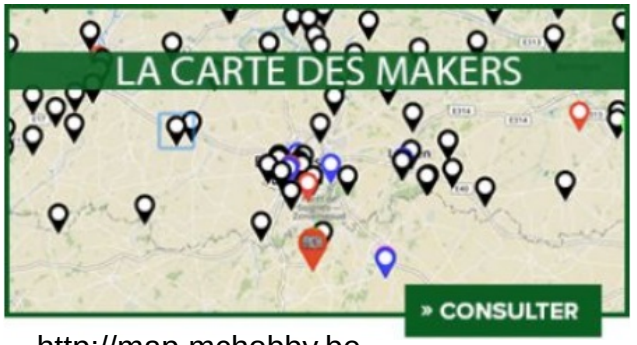
7 Rules of ~~Life~~ RADIO

- **Rule #1:** Use short, high quality and thick antenna cables.
- **Rule #2:** An SWR below 2 is acceptable (less than 11% of power is reflected so we have much of the power available for transmission).
- **Rule #3:** Always connect an antenna to the sender (otherwise 100% of signal is reflected, which may kill the sender)
- **Rule #4:** Keep the polarization of your antennas the same way.
- **Rule #5:** The more dBi, the more power in one direction.
- **Rule #6:** With a proper antenna setup, the distance in air is not an issue if we have a line of sight.
- **Rule #7:** Longer is not always better for antennas. Smarter is better.

Andreas Spiess – Video tutorial

https://youtu.be/J3PBL9oLPX8

Finding Radio Amateur Club



http://map.mchobby.be