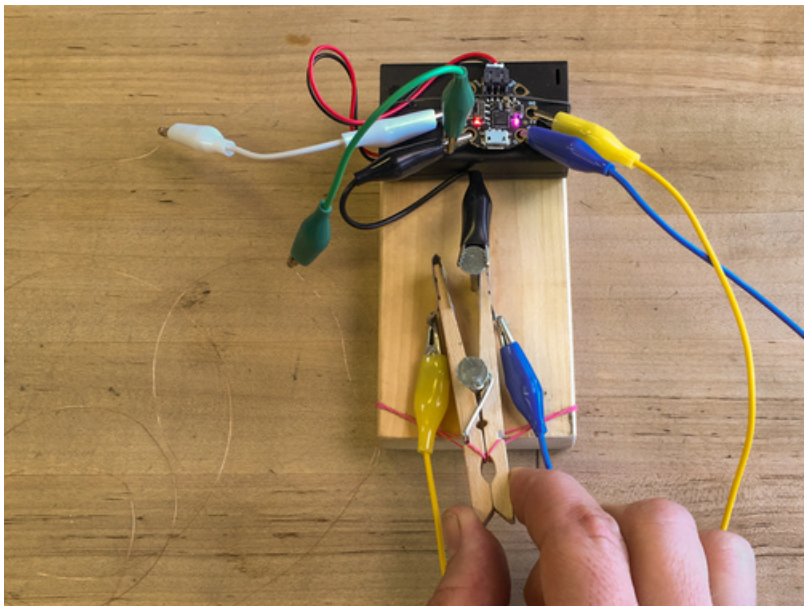
adafruit learning system

AM Radio Morse Code Paddle

Created by John Park



Last updated on 2018-08-22 04:06:20 PM UTC

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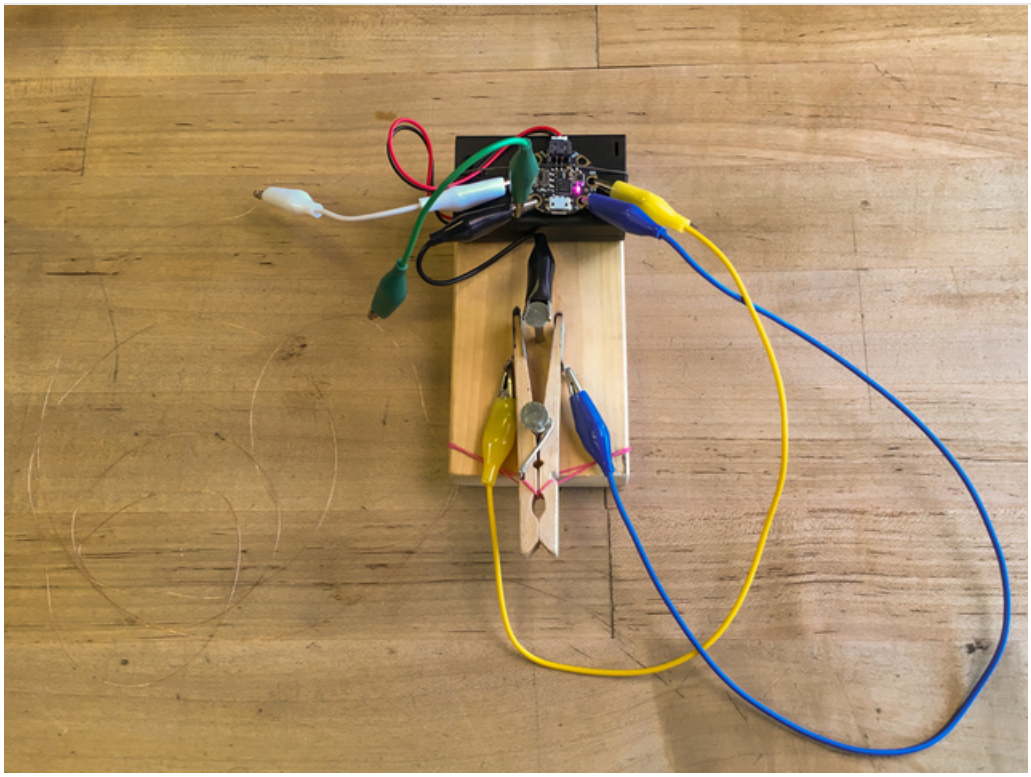
Overview



Having the ability to send secret messages is a critical spy skill. By harnessing the power of radio waves and using Morse code, you can transmit your plans to your base station for your fellow operatives!

The Gemma M0 can act as a basic *AM radio transmitter* by taking advantage of M0 chip's digital-to-analog converter (**DAC**) and direct memory access (**DMA**). Here's more info (https://adafru.it/Cki) on how this clever hack by our own Phillip Burgess works.

You'll tell other operatives nearby to tune in to your chosen frequency, and then you'll send your Morse messages with a specially built Morse code keyer attached to the Gemma M0.

Parts

1 x Gemma M0
Wearable microcontroller board
ADD TO CART

1 x Woven Conductive Fabric
For building contact switches
ADD TO CART

1 x 3x AAA Battery Holder
with On/Off Switch and 2-pin JST
ADD TO CART

1 x AAA batteries
3 pack

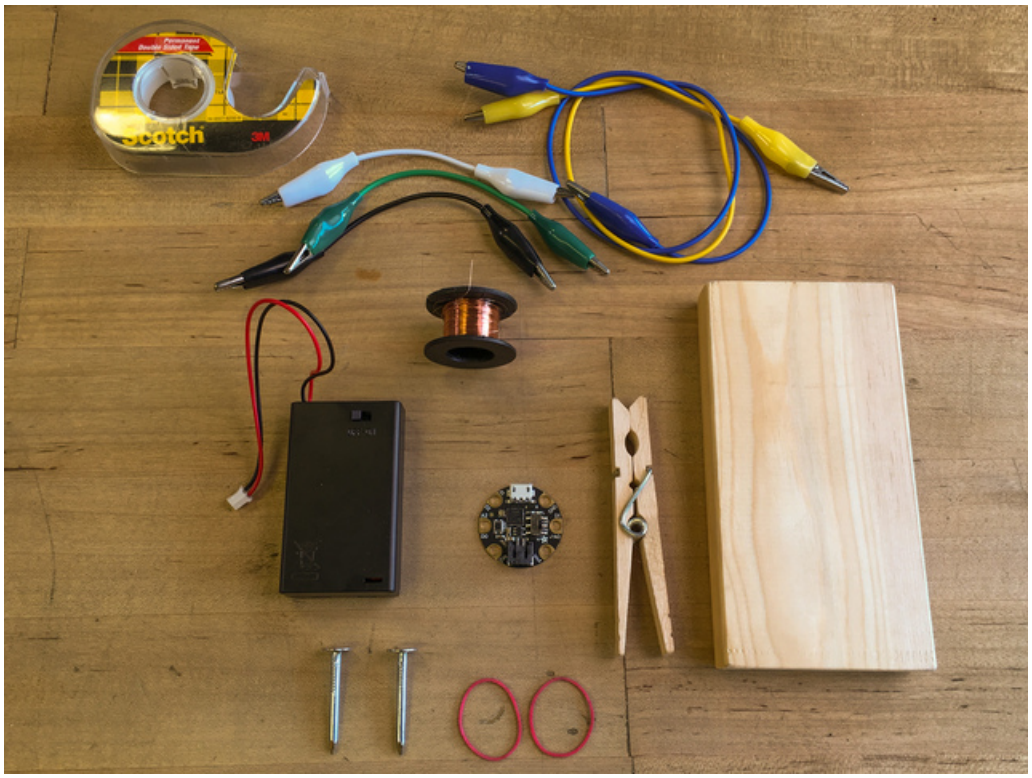
ADD TO CART

1 x Enameled Copper Magnet Wire
makeshift antenna

ADD TO CART

1 x USB Cable
A/MicroB - 6"

ADD TO CART



Materials

In addition to the above parts, you'll also need:

- An AM radio to tune in the Morse transmissions
- Wooden clothespin
- Small block of wood, approximately 2-1/2" x 5" x 3/4" (a.k.a. a 5" length of nominal 1" x 3" lumber)
- Two nails that fit in the clothespin spring coil and are electrically conductive
- Double stick tape
- Two small rubber bands
- Stranded wire or alligator clip leads

Set up your Gemma M0

Setup

We'll code this project using the Arduino IDE. First, install the Arduino IDE by following this guide https://learn.adafruit.com/adafruit-gemma-m0/arduino-ide-setup (https://adafru.it/Cib)

https://adafru.it/f1P

https://adafru.it/f1P

Then, follow this guide on using the Gemma M0 with the Arduino IDE https://learn.adafruit.com/adafruit-gemma-m0/using-with-arduino-ide (https://adafru.it/AIN)

Be sure to set up the Arduino Preferences with this URL in the **Additional Boards Manager URLs** field:

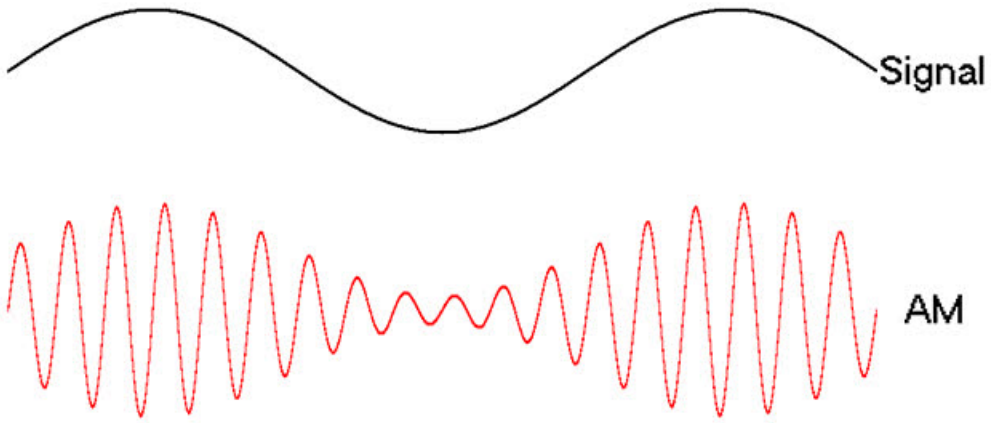
```
https://adafruit.github.io/arduino-board-index/package_adafruit_index.json
```

Add the proper boards to the Board Manager for the Gemma M0:

- **Adafruit AVR Boards** - Includes support for Flora, Gemma, Feather 32u4, Trinket, & Trinket Pro.
- **Adafruit SAMD Boards** - Includes support for Feather M0, Metro M0, Circuit Playground Express, Gemma M0 and Trinket M0
- **Arduino Leonardo & Micro MIDI-USB** - This adds MIDI over USB support for the Flora, Feather 32u4, Micro and Leonardo using the arcore project (https://adafru.it/eSI).

Libraries

The Gemma M0 doesn't have a traditional AM radio transmitter circuit built in, but it is possible to transmit by using this clever DAC/DMA hack. https://learn.adafruit.com/circuit-playground-express-dac-hacks/overview (https://adafru.it/Ckj)



In short, it is possible to use the digital-to-analog converter (DAC) in an unintended way by sending it messages very quickly using direct memory access (DMA) — so quickly that the frequency of the analog write pulses actually generate AM radio waveforms!

Check out this page for more info: https://learn.adafruit.com/circuit-playground-express-dac-hacks/transmitting-am-radio (https://adafru.it/Cki)

Install the ZeroDMA library as directed here https://learn.adafruit.com/circuit-playground-express-dac-hacks/overview#getting-started (https://adafru.it/Ckj)

https://adafru.it/lnd

https://adafru.it/lnd

Then, install the AMRadio library as shown here https://learn.adafruit.com/circuit-playground-express-dac-hacks/transmitting-am-radio (https://adafru.it/Cki)

https://adafru.it/wAf

https://adafru.it/wAf

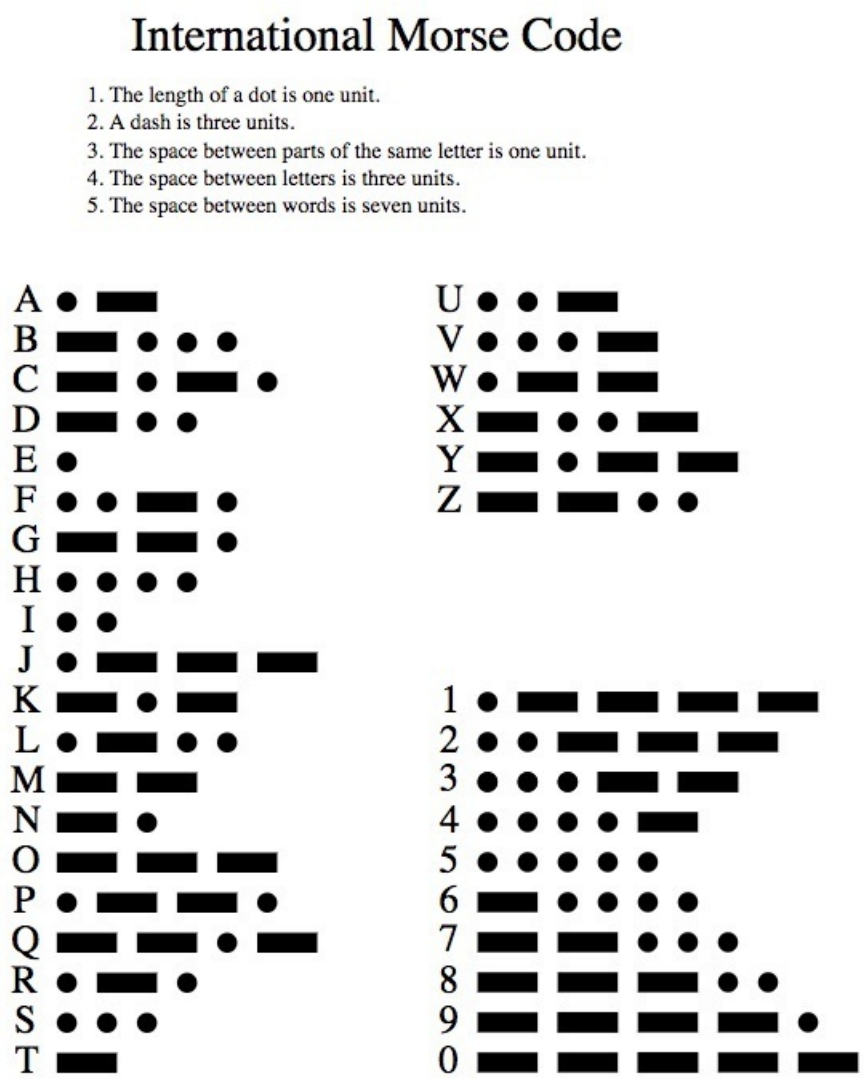
To test it all out, and confirm that it's all working, in Arduino open **Examples** > **Adafruit_AMRadio** > **melody** and upload it to your Gemma M0. Clip a wire to the A0 pin to act as an antenna. Hold it close to an AM radio tuned to 540 AM and you'll hear a familiar song!

Now that we know it's working, we'll use a modified version of the original code to send Morse code messages, instead of tone melodies.

What is Morse Code?

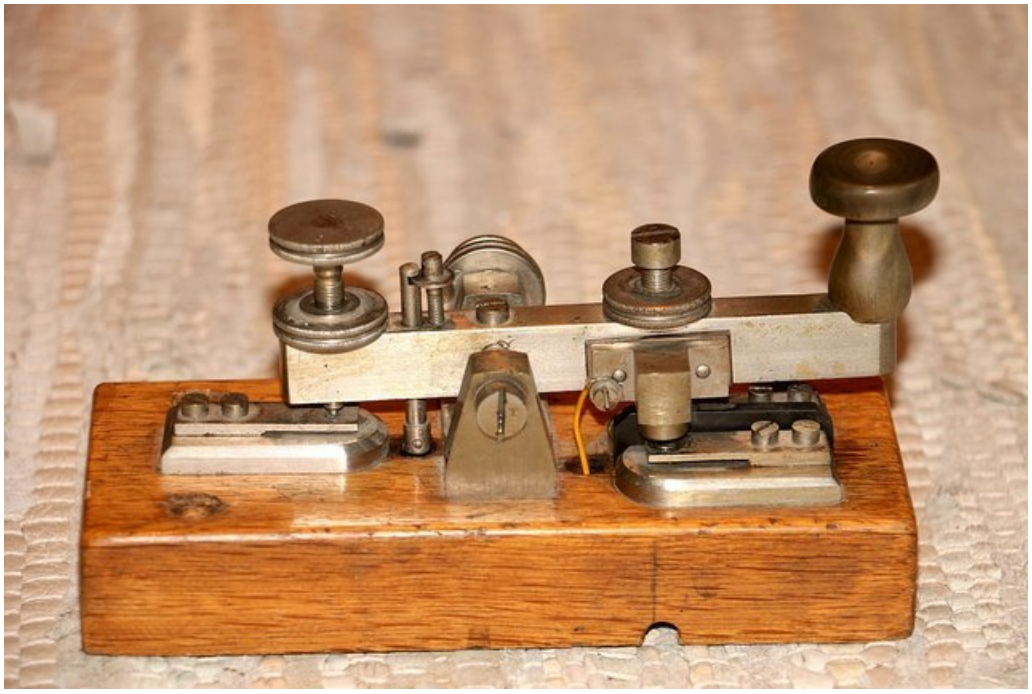
Morse Code

Morse code follows conventions on timing for the lengths of dots and dashes, spaces between elements, spaces between letters, and spaces between words.



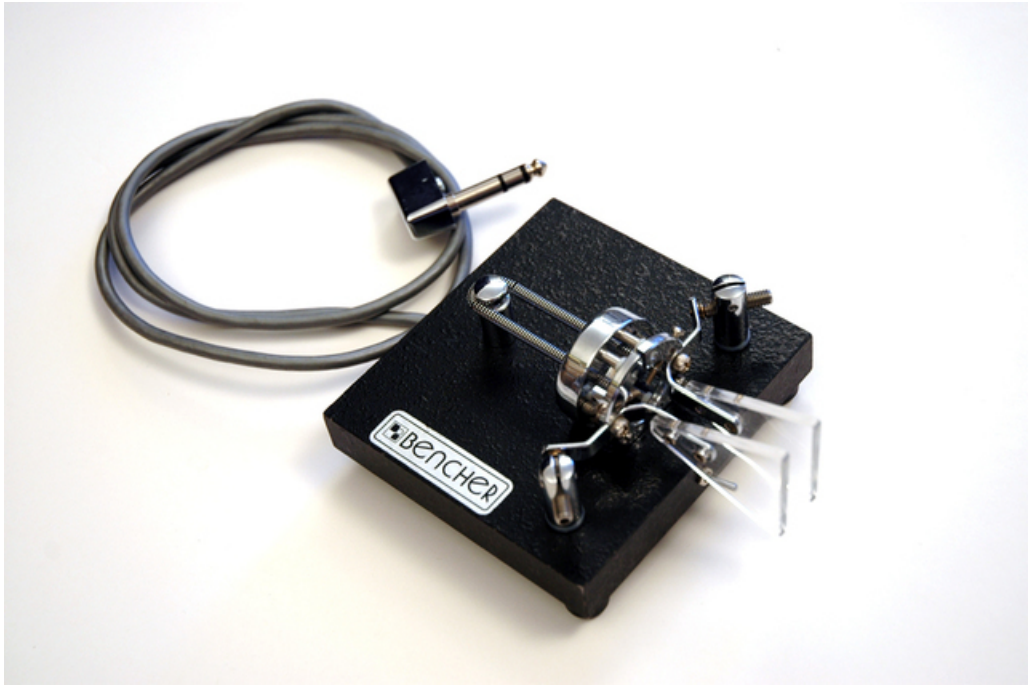
Keyers

In the original telegraph system, keyers used a single button straight key, kind of like a typewriter key, and held it for short or long durations.



Did you know that electronics distributor Digi-Key was named after founder Ronald Stordahl's "Digi-Keyer Kit" he designed for sending radiotelegraph code? It's true!

An alternative to the straight key are paddles (either "bug" or "iambic" style) that can be pressed in two possible directions — a push with the index finger is a long duration '`dash`', while a push with the thumb is a short '`dot`'. By keeping the paddle pressed in one of the directions, it will automatically repeat with proper spacing between dots or dashes.



The letter 'D' for example, is made with a '`dash-dot-dot`'. The dots and dashes are separated by inter-element gaps,

which are equal to a dot in duration, so it really looks like '`dash-gap-dot-gap-dot`'.

When using a traditional straight Morse code key, the sender would use one finger to manually hold for the correct '`dash`' duration, release, pause for the correct '`gap`' duration, tap a '`dot`', release, pause for '`gap`' duration, and tap another '`dot`', and release.

A Morse code paddle automates some of this process. By tapping the paddle with the thumb from left to right, a `'dot'` is sent with the correct duration no matter if the paddle is only very quickly tapped. In other words, the timing is taken care of. By pushing the paddle with the index finger from right to left, the `'dash'` duration is automatically sent. And, holding the paddle continuously repeats the dot or dash (depending on thumb or index finger direction) with the proper gap.

The Arduino code will set the dot duration at 100ms, and then derive the gap space between elements -- 1x a dot - and duration of dashes -- 3x a dot - from that.

It will be up to you to pause the appropriate time between letters (3x a dot length) and words (7x a dot length).

Here's an example: **SOS** `... --- ...` can be sent by paddling thumb and holding for three dots, index finger for three dashes, and thumb for three dots. That's only three presses with the paddle for the complete word, versus nine presses on a traditional Morse key!

Arduino Sketch

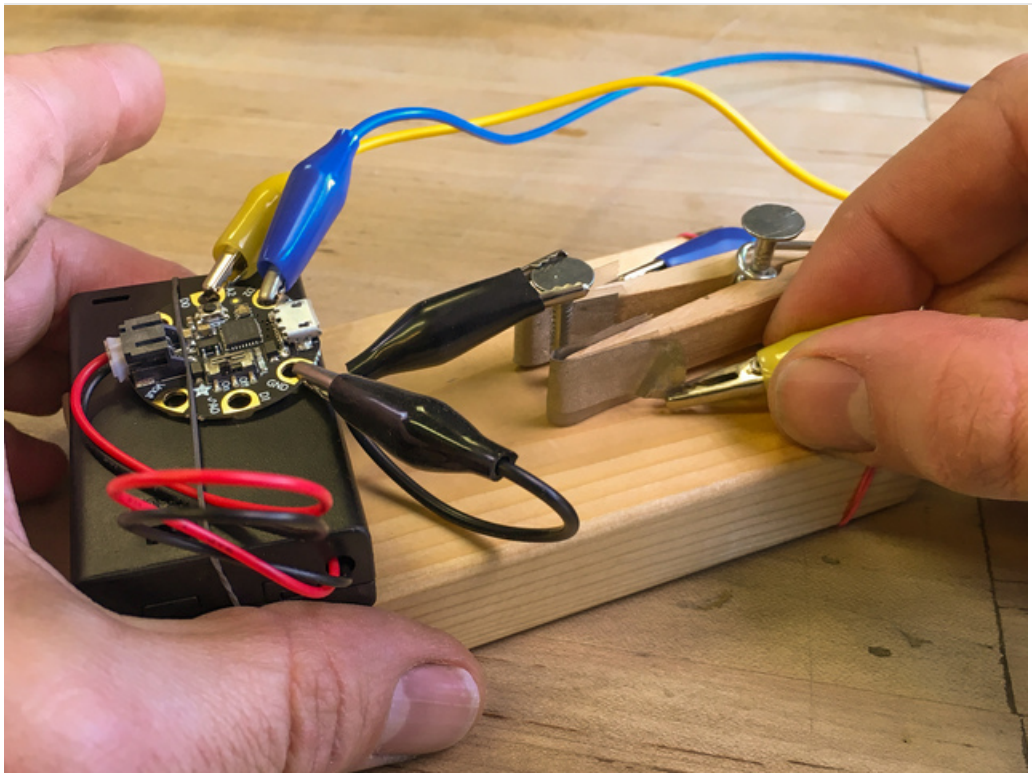
Copy the code here, paste it into a new Arduino sketch, and then save it as `AM_Radio_Morse.ino`. Now, upload it to your Gemma M0 board.

```
// For Adafruit_AMRadio library -- Morse code transmits on AM 540.
// Connect antenna (40" wire) to pin A0 and GND
// RANGE IS LIMITED TO A FEW FEET
// Morse "dot" key is a contact switch connected to D2 and GND
// "Dash" key is switch connected to D0 and GND
// Adapted from Phil Burgess's AMRadio sketch

#include <Adafruit_AMRadio.h>

Adafruit_AMRadio radio;

const int buttonDotPin = 2; //pushbutton pin for dit
const int buttonDashPin = 0; //pushbutton pin for dah
const int ledPin = 13; //to light the onboard LED

int buttonDotState = 0; //to store button state
int buttonDashState = 0;

//Morse varaiblas
const int PITCH = 680;
const int DOT = 100; //duration of short dot in millis
const int DASH = DOT * 3;
const int GAP = DOT;


void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(buttonDotPin, INPUT_PULLUP);
  pinMode(buttonDashPin, INPUT_PULLUP);

  radio.begin(540000); //start radio object, transmits at 540MHz AM
}


void loop() {
  buttonDotState = digitalRead(buttonDotPin);
  buttonDashState = digitalRead(buttonDashPin);

  if (buttonDotState == HIGH) {    // not pressed
    digitalWrite(ledPin, LOW);   // light is off
  }
  else {                         // pressed
    digitalWrite(ledPin, HIGH);  // light on
    radio.tone(PITCH, DOT);
    delay(GAP);
  }
  if (buttonDashState == HIGH) {    // not pressed
    digitalWrite(ledPin, LOW);   // light is off
  }
  else {                         // pressed
    digitalWrite(ledPin, HIGH);  // light on
    radio.tone(PITCH, DASH);
    delay(GAP);
  }

  delay(15);
}
```

You can test this out by, again, holding the board near the AM radio tuned into 540MHz, and then use a piece of wire to bridge **D0** or **D2** to **GND**. Each time you close the contact, it will beep either a "di" or a "dah" with proper duration and spacing.

Next, we'll turn this into a proper Morse code keying paddle!

Build the Morse Code Paddle



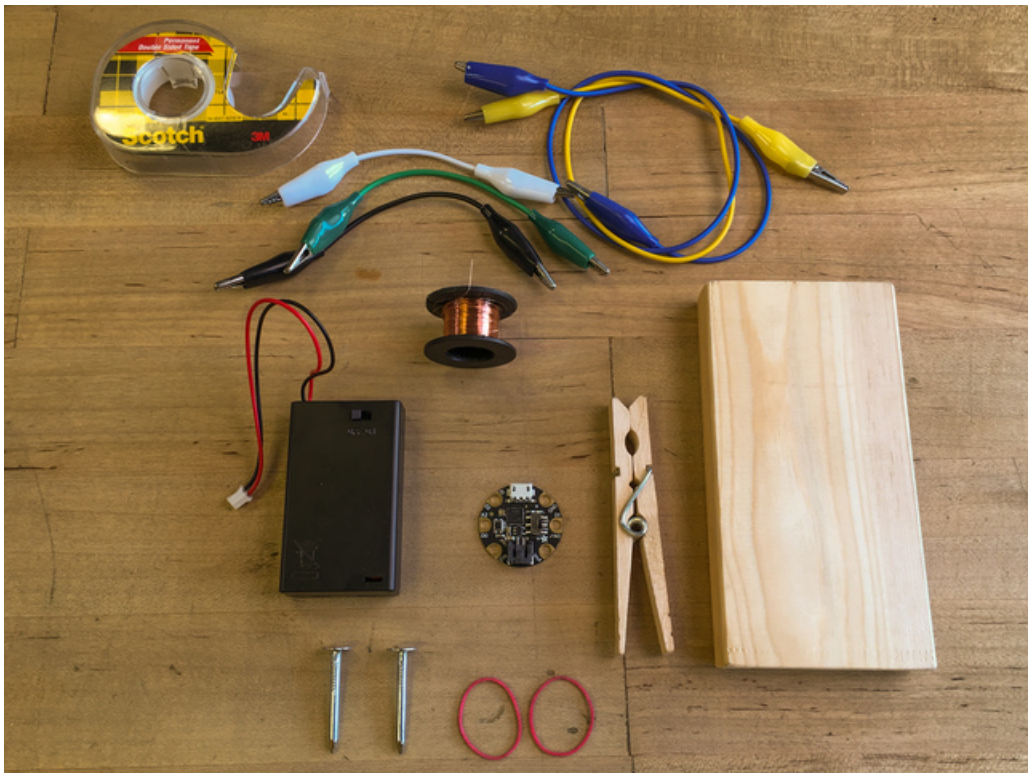
Contact Switch Inputs

In our code, the digital inputs **D0** and **D2** are used as switches. The pins are set to `INPUT_PULLUP` mode, which means they will normally read `HIGH`, until they are sent to **ground** by a button press, which will cause them to read `LOW`.

The program checks these pins and when one goes `LOW` (is pressed) it broadcasts the tone for the appropriate duration, pauses for the gap duration, and repeats until the pin goes low again.

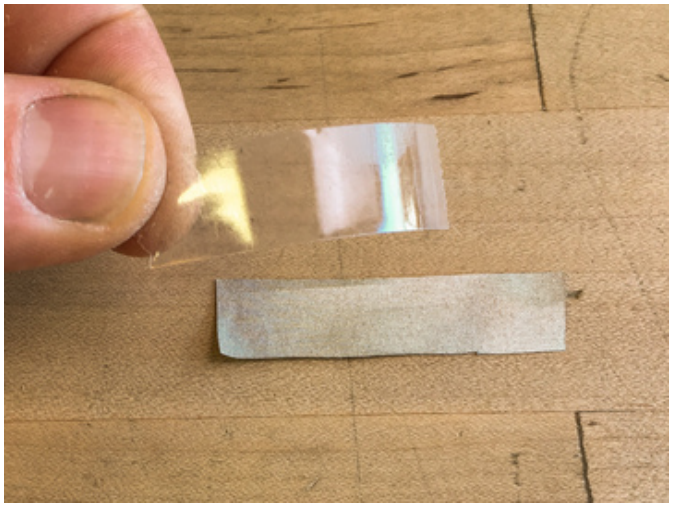
Paddle Construction

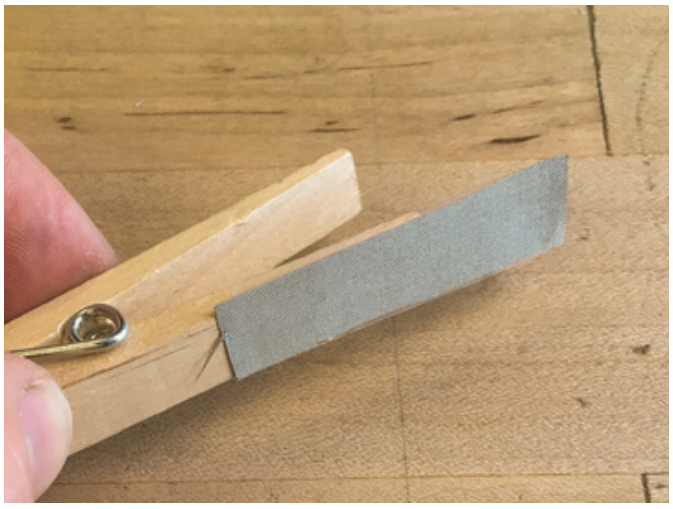
We can use any button as a key switch or pair of buttons as a paddle. If you want a more authentic paddle experience, you can build a simple one from a clothespin, a block of wood, two nails, rubber bands, and a bit of conductive fabric (or aluminum foil), some wire, and tape.



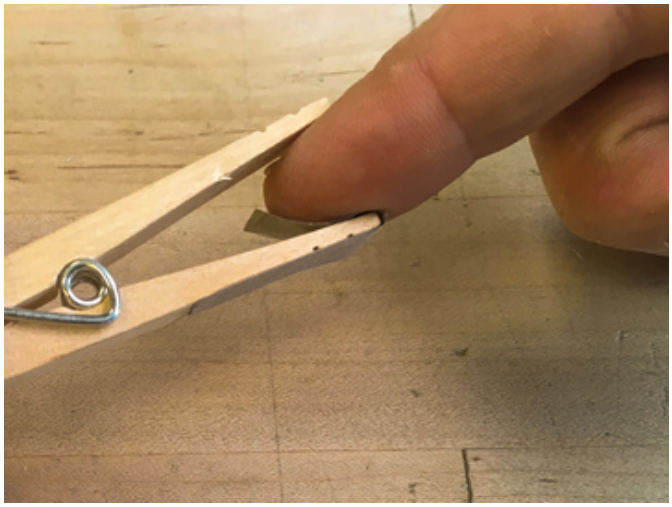
Clothespin Contacts

First, we'll make two contact switches on the clothespin. These will be two pieces of conductive material -- either conductive woven fabric, or aluminum foil -- which can be connected to the **D0** and **D2** pads on the Gemma M0, and which will be able to close the circuit to ground when they contact a nail connected to **GND.**





- First, cut two strips of the material to size so they'll each wrap around the ends of the clothespin
- Next, place a piece of double stick tape on the material, leaving a bit of extra material on one end for connecting your wires
- Press the material strips to the ends of the clothespin as shown
- Wrap the material around to the inside as well -- this is where it will contact the nail

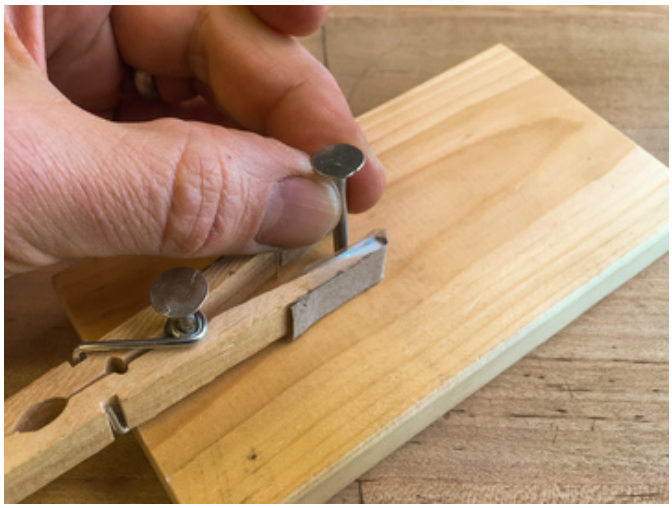


Paddle Board

Now, we'll make the base for the keying paddle, by fastening the clothespin to a small piece of wool with a nail, and driving in another nail for the ground contact.

Pivot Point

- Measure and mark a point in the center of the board's width (1-1/4" from either side) and 3/4" up from the bottom edge
- Place a nail through the clothespin's spring coil and hammer it into this marked point as shown -- be careful not to hammer too deeply or the clothespin won't be able to rotate



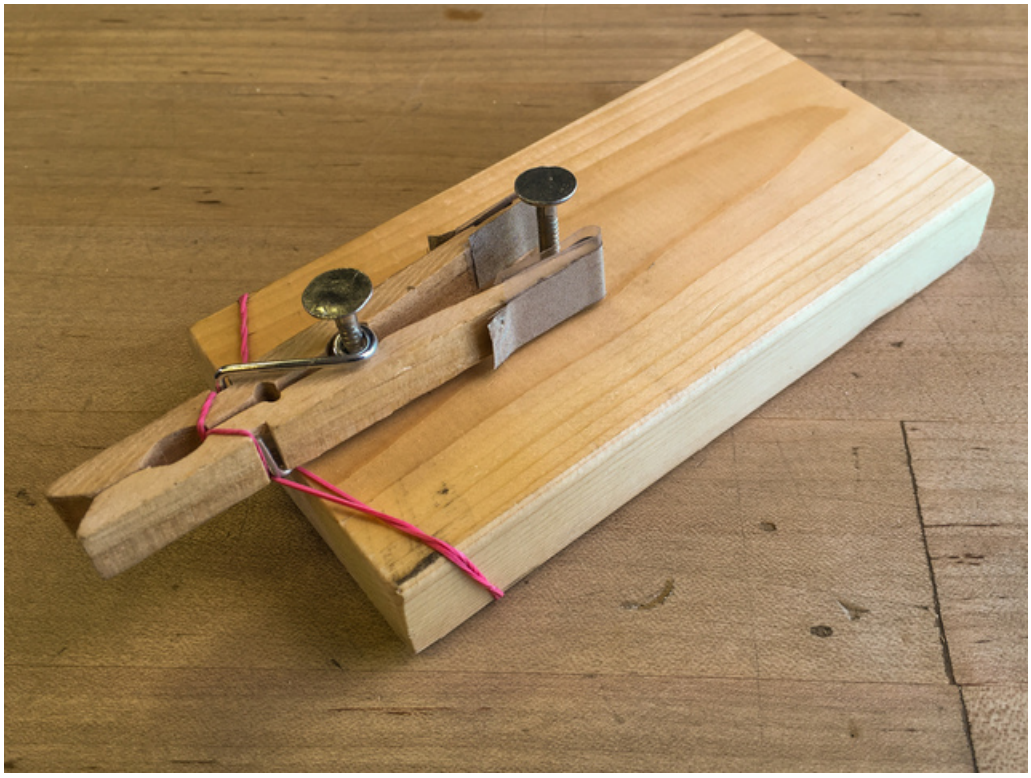
Contact Nail

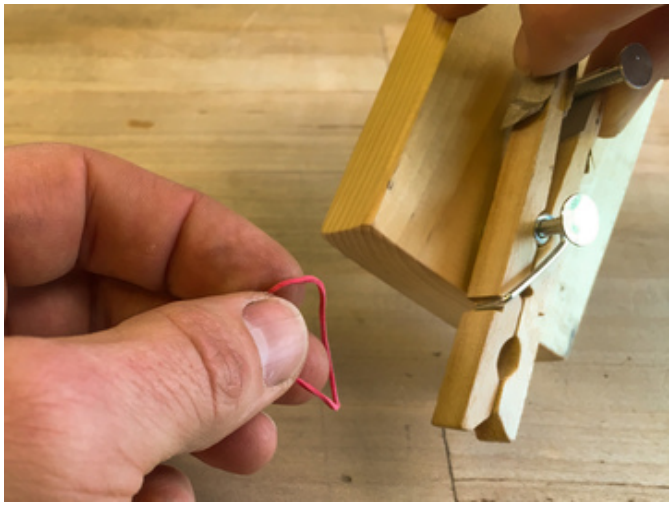
- Mark a point in the center of the board's width, about 2" up from the bottom edge -- this should be right in the middle of the clothespin's legs
- Hammer in the other nail as shown

This is the point either paddle contact will touch when pressing the paddle from either direction.

Self Centering

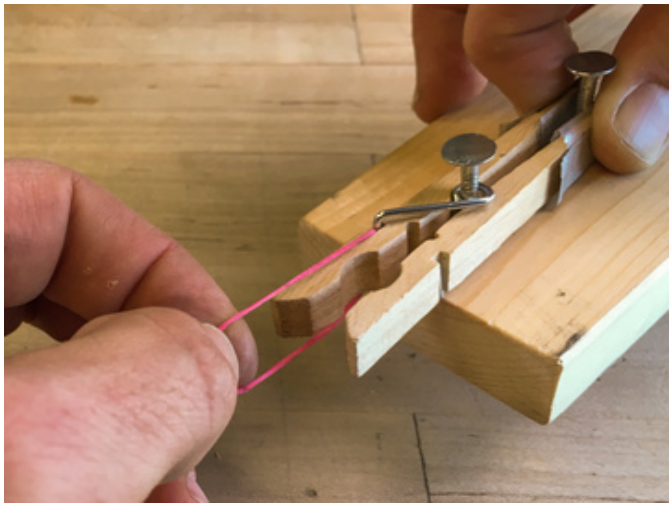
We want the paddle to return to its home position after every tap. To do this, we'll use a pair of rubber bands pulling equally to the left and right on the clothespin.

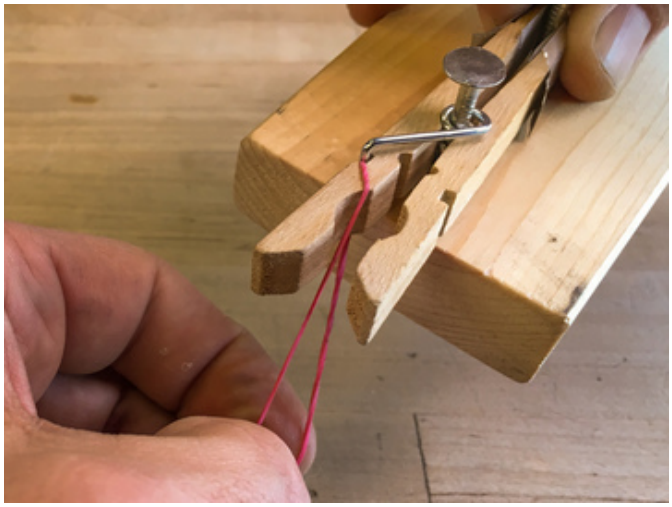


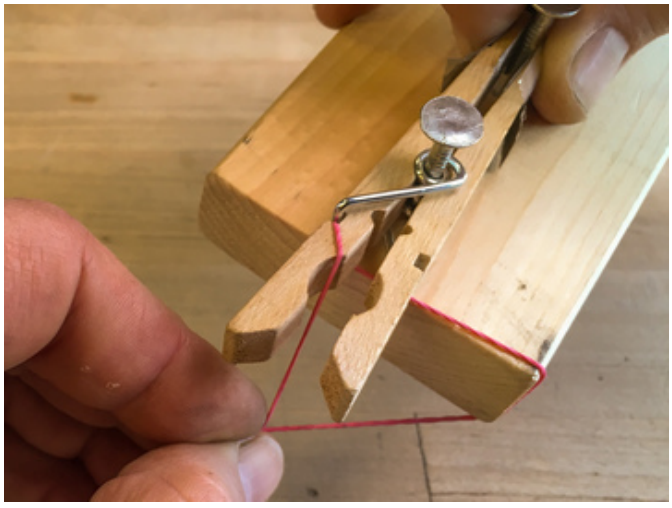


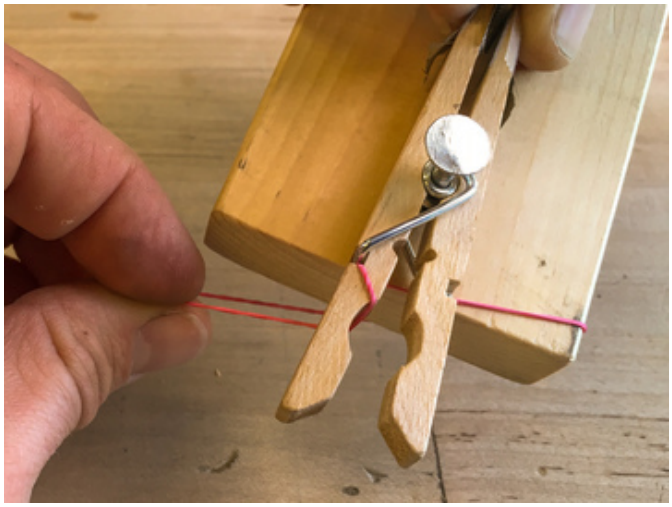
- Squeeze the clothespin open
- Loop one rubber band around the left side of the clothespin head as shown
- Twist the band to capture the head, then wrap it around the wooden board base as shown
- Repeat this for the other side

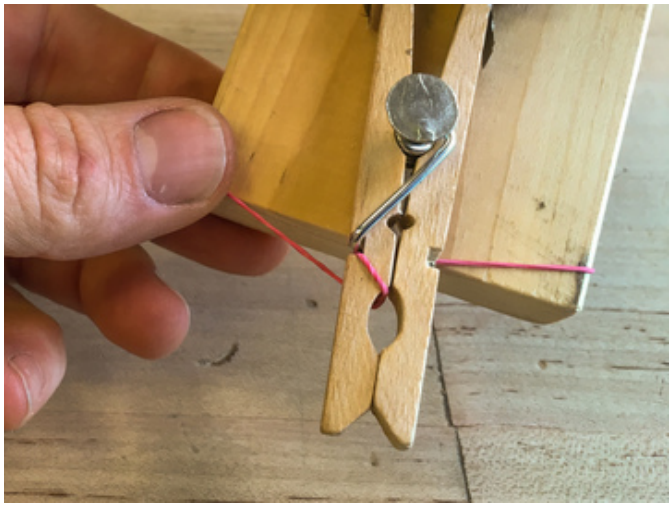
You may need to pull each band left or right to adjust it and get the clothespin legs centered an equal distance apart from the contact nail.

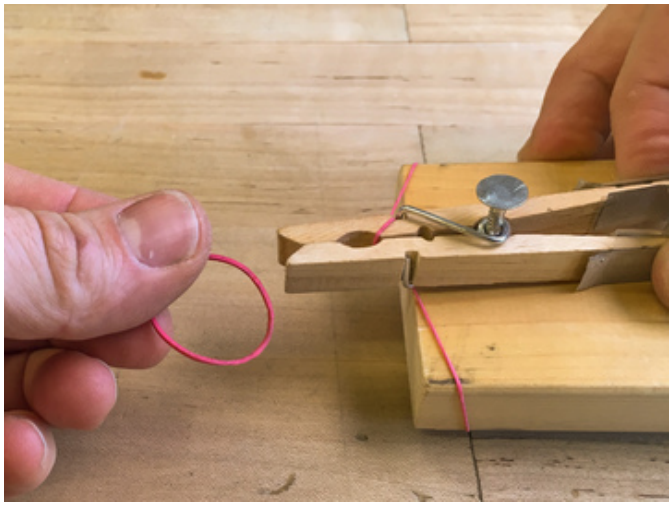


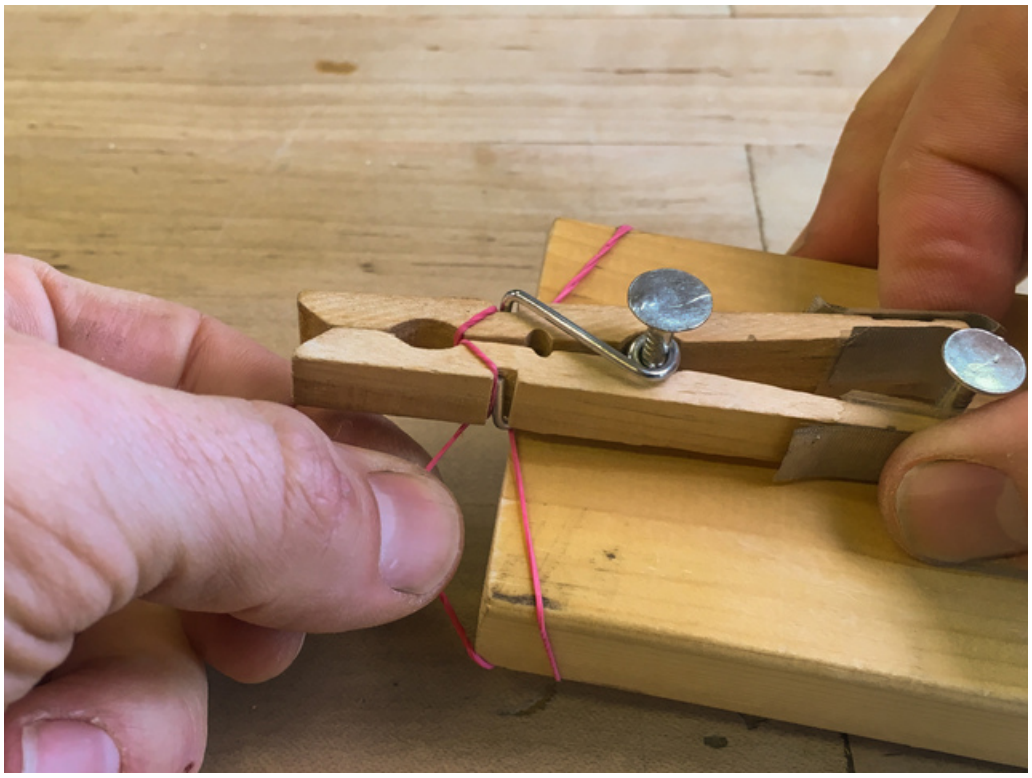










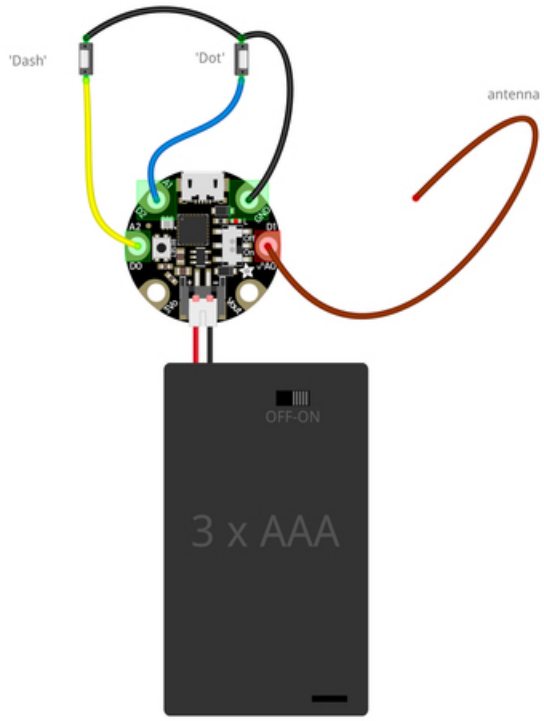


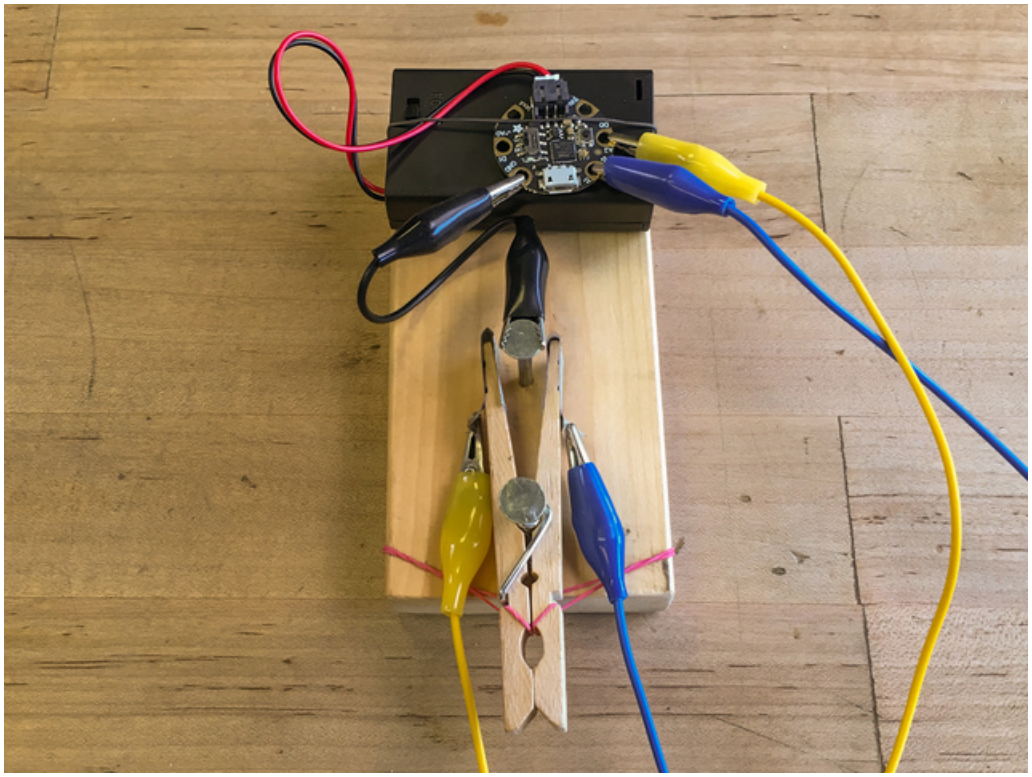
Now you can tap the paddle from either side and test out the action! It will contact the nail and then return to home position.

Switch Wiring

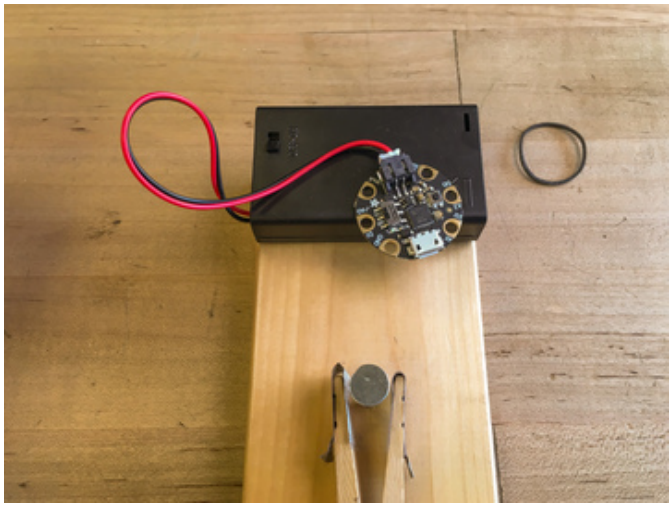
We'll now wire the **D0, D2,** and **GND** pads on the Gemma M0 to the left, right, and ground contacts respectively on the clothespin conductive material and contact nail.

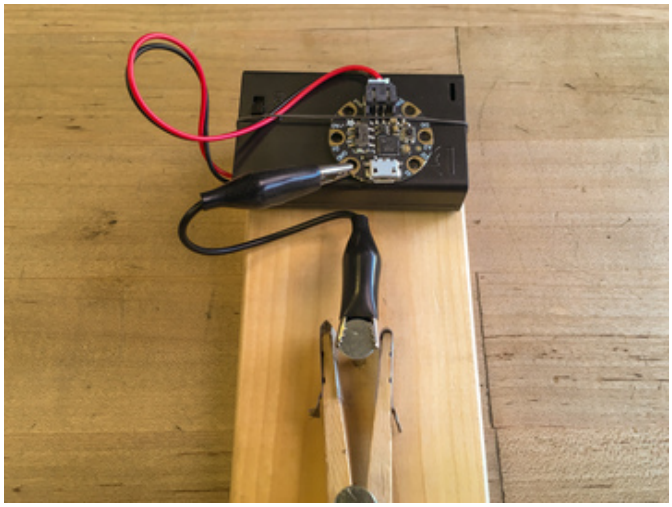
This is what the circuit looks like using regular buttons, but our contact switches will serve the same purpose as these buttons. We'll add an antenna wire later.

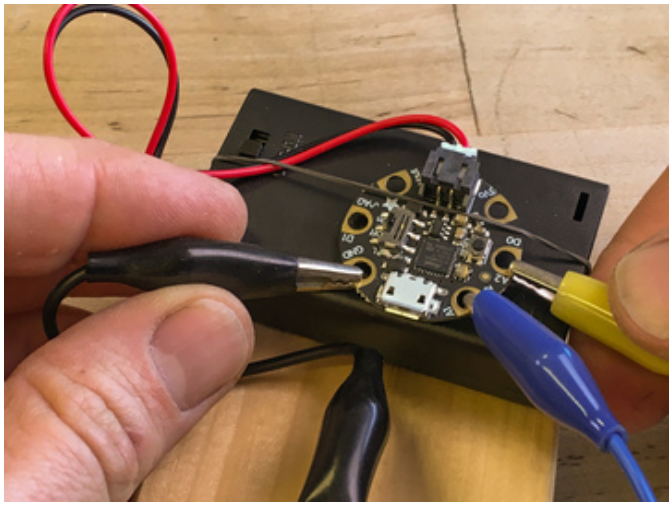




- Plug the Gemma M0 into the battery box, then secure both to the end of the board with a rubber band or tape
- Connect the Gemma M0's **GND** pad to the contact nail with an alligator clip lead (or twist the ends of

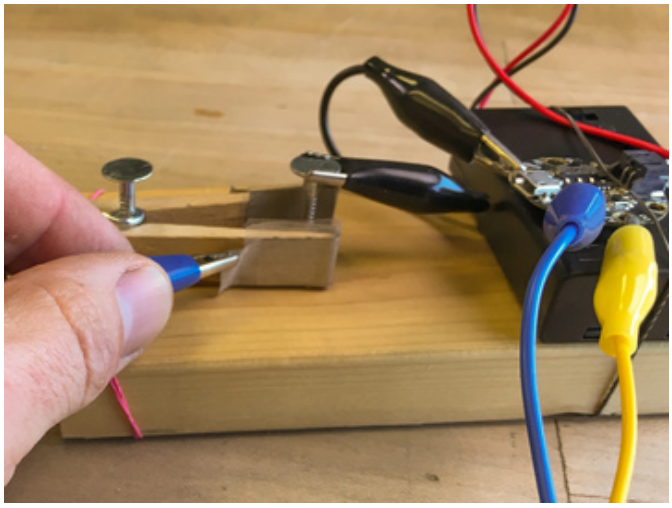


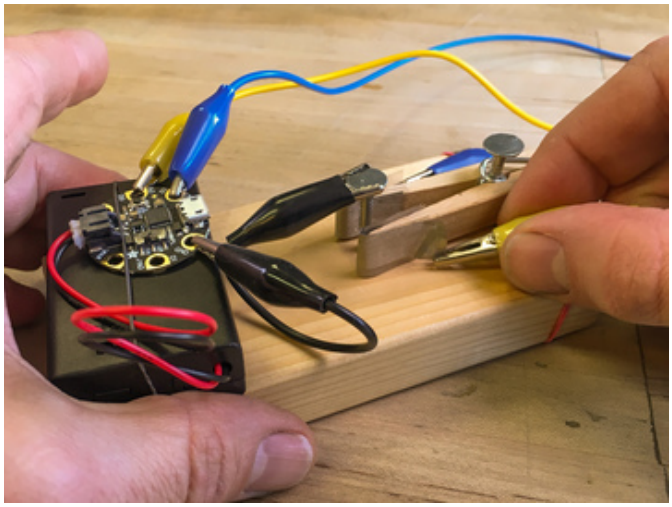




solid core hookup wire or stranded wire around the pad and the nail if you don't have alligator clip leads)

- Connect a wire from the Gemma M0's **D2** pad to the conductive material on the right leg of the clothespin paddle
- Connect a wire from the **D0** pad to the left leg conductive material





If you're eager to test your progress so far, you can turn on the battery's on/off switch and tap the paddle in either direction -- you will see the on-board LED light up for a long dash when you press with your index finger, and a short dot duration when tapped with your thumb.

But, before we can hear anything transmitted over the AM radio waves, we need to build an antenna.

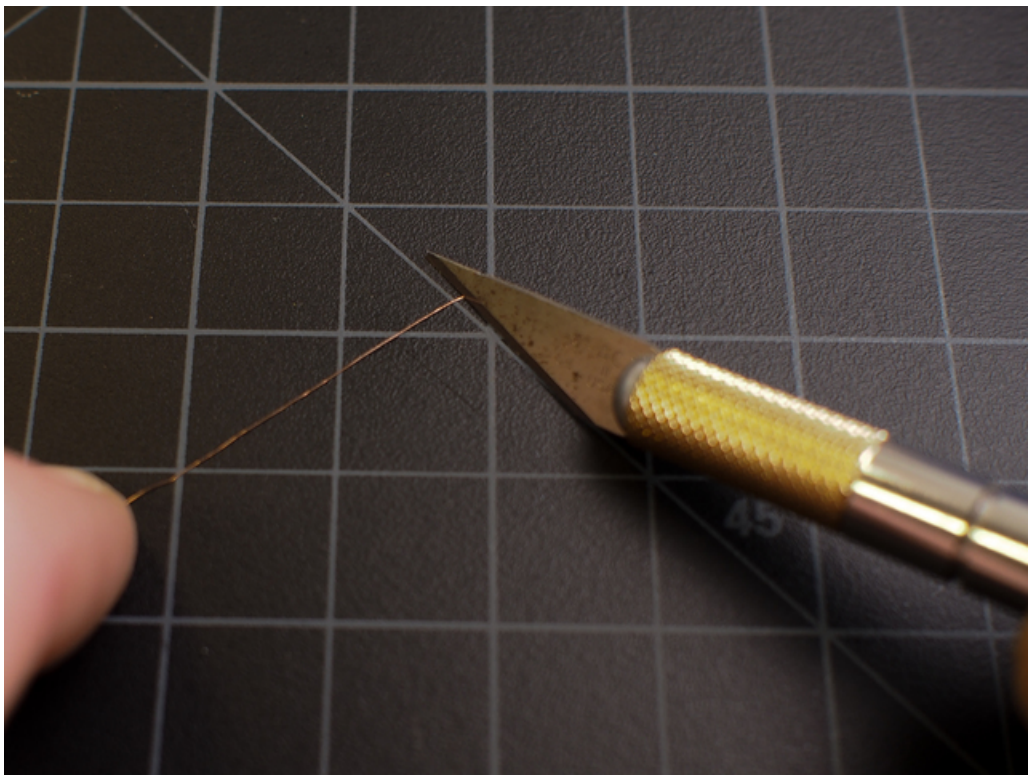
AM Antenna

AM Antenna

An AM radio transmitter requires an antenna to radiate its signal to the receiver. An ideal antenna would be very, very long (usually coiled for most of this length to keep it small), but we can get a decent signal by using a 40" wire that is connected to the output signal pad **A0.** (You can effectively double the range by using an 80" length of wire, and gain a bit more at 120", however beyond that the ambient noise will increase a lot.)

To make this simple antenna, measure and cut a 40" length of enamel coated copper wire (called "magnet" wire because it's often wound into coils to create electromagnets.)

The wire is coated in enamel, so it is electrically insulated. We need to expose a bit of the copper at onw to connect it to the Gemma M0. You can use a flame to burn away the enamel, or scrape it away carefully with a knife blade as shown here.



Use alligator clip leads to connect one of the antenna wire to **A0** on the Gemma M0.

Special thanks to Jan Goolsbey (https://adafru.it/Ckk) for his great insights on antenna design and testing for this guide. Here are his notes on the antenna experiments he conducted:

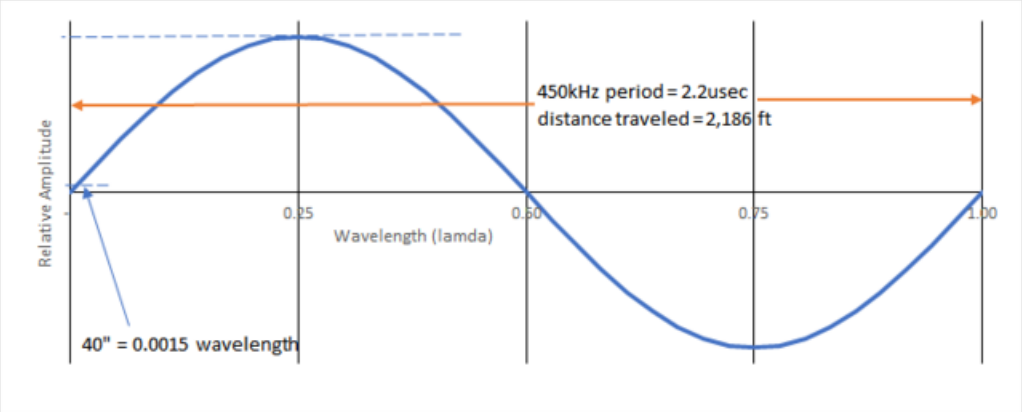
> A 40- to 80-inch long wire antenna is the better solution. After looking at the carrier and modulation waveform on the 'scope, I began to test it without an antenna, playing with loading on the analog output pin. As the load dropped below 5k ohms, I noticed an increase in radiated energy and signal distortion. When shorted to ground, the circuit created a distorted tone with lots of carrier sidebands, but could only be picked up by the radio within about 10 inches. Adding a 40-inch antenna (shorted to ground) seemed to increase the range, but only along the length of the antenna wire -- the signal died out quickly if the radio was more than about 10 inches away from the antenna wire. Testing an open-ended 40-inch long wire was the next test. Without a ground connection, the range

was about 8 to 10 feet. Adding a 40-inch ground plane wire (dipole configuration) to the ground had no noticeable effect.

Increasing the antenna length to 80 inches almost doubled the range to 18 feet. 120 inches increased it to about 25 feet. The range stayed at 25 feet when the antenna length was increased to 160 inches. The ambient noise at the low end of the band was just too much for the Gemma to overcome even with longer antenna lengths.

I also created a helical antenna using the 160-inch antenna wire wound around a paper towel tube. The range dropped to about a foot. In theory, 600 feet of wire wound around a tube could work if you need a more compact antenna than a 586-foot quarter-wave wire length. I'll leave that idea there for the discussion...

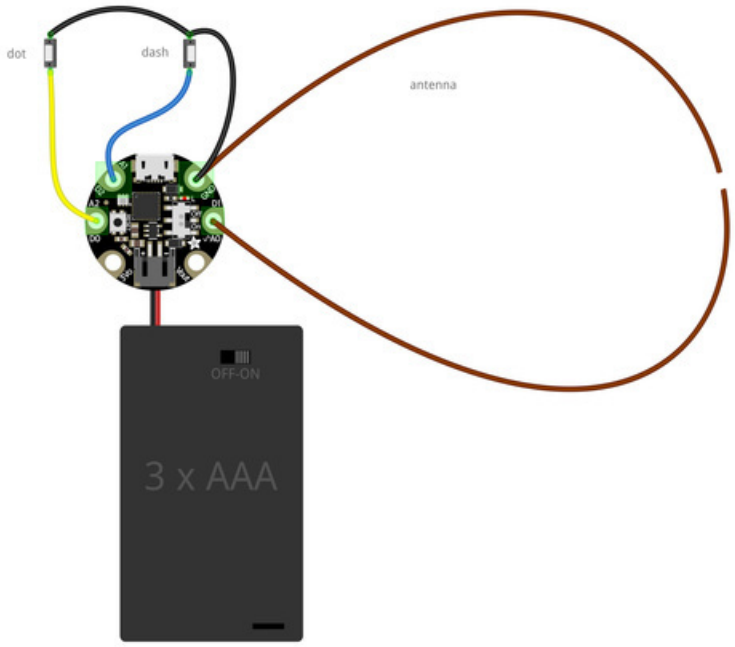
The basis of it is understanding how a wave travels over time. In this case, it's a 450kHz sine wave traveling through air at 186,272 mi/sec. Note that synchronized peak energy (the absolute value of the area under the curve) happens at a full wavelength, 3/4, 1/2, and 1/4. Anything between those values creates a moving wave across the length of the antenna, lowering the antenna's ability to transmit the power of the wave. Our 40-inch antenna is very inefficient since it represents only 0.0015 of the 450kHz wavelength.



Tuning an antenna is the process of reducing the destructive energy caused by wave movement across the antenna. It's accomplished by trimming the length of the antenna to match the 0.25, 0.50, 0.75, or 1.0 wavelength nodes of the carrier wave.

Dipole Experiment

If you'd like to try some of these same experiments, here's an example of a dipole antenna, which would have equal lengths of wire connected to **A0** and **GND**.



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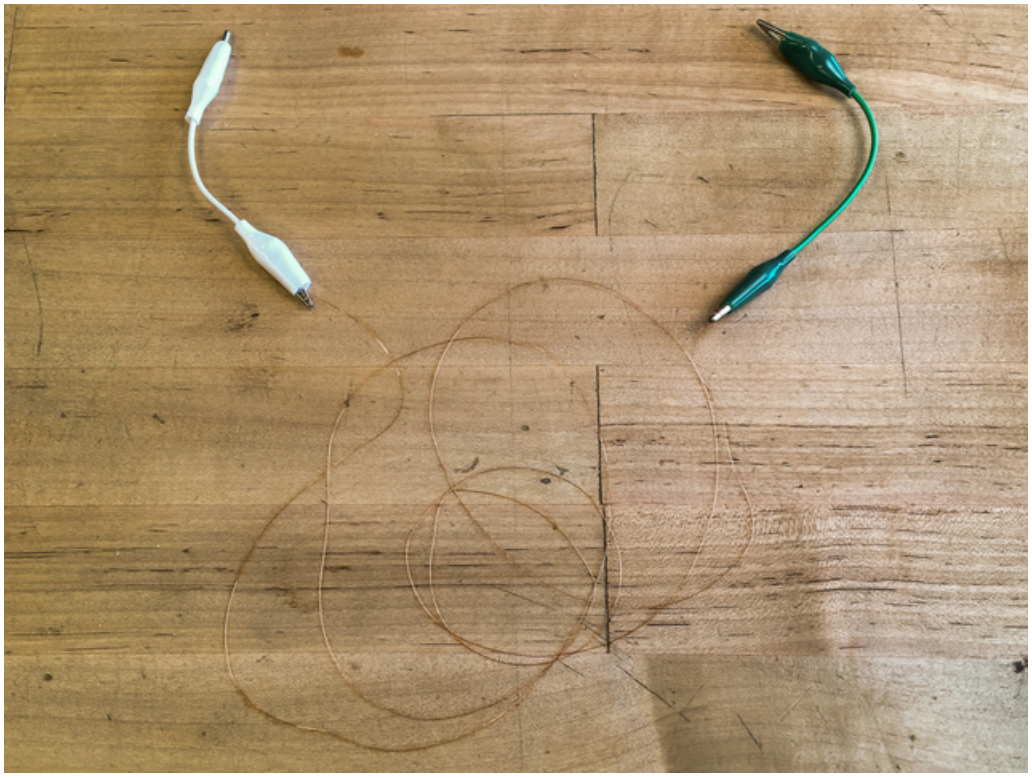
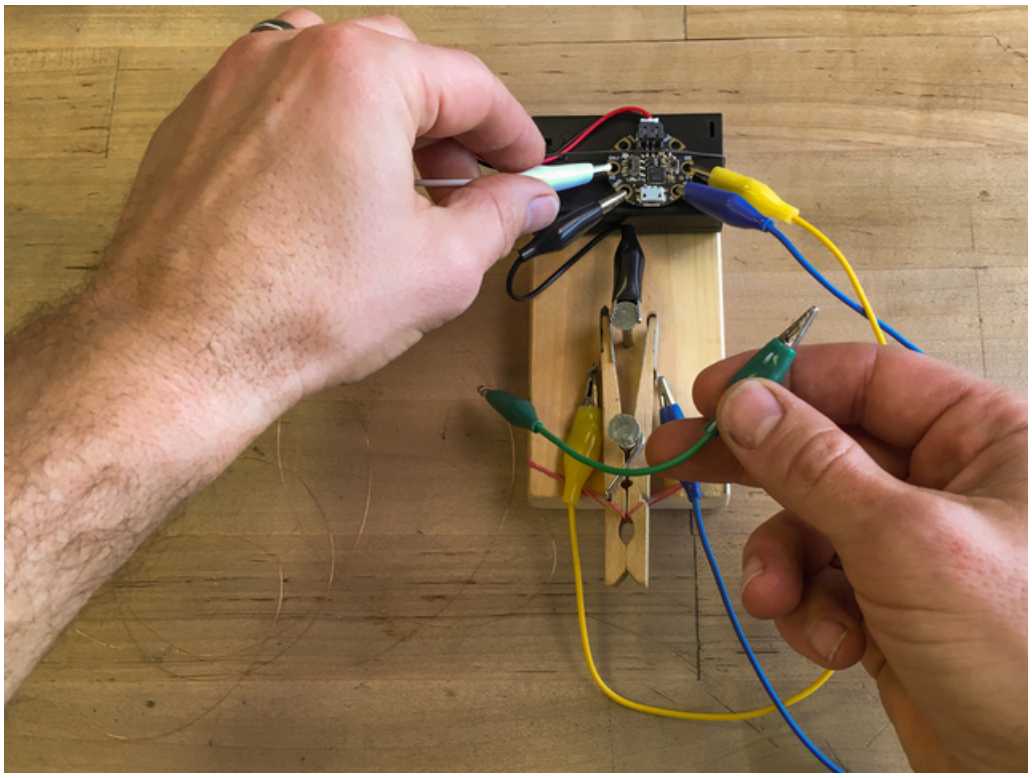
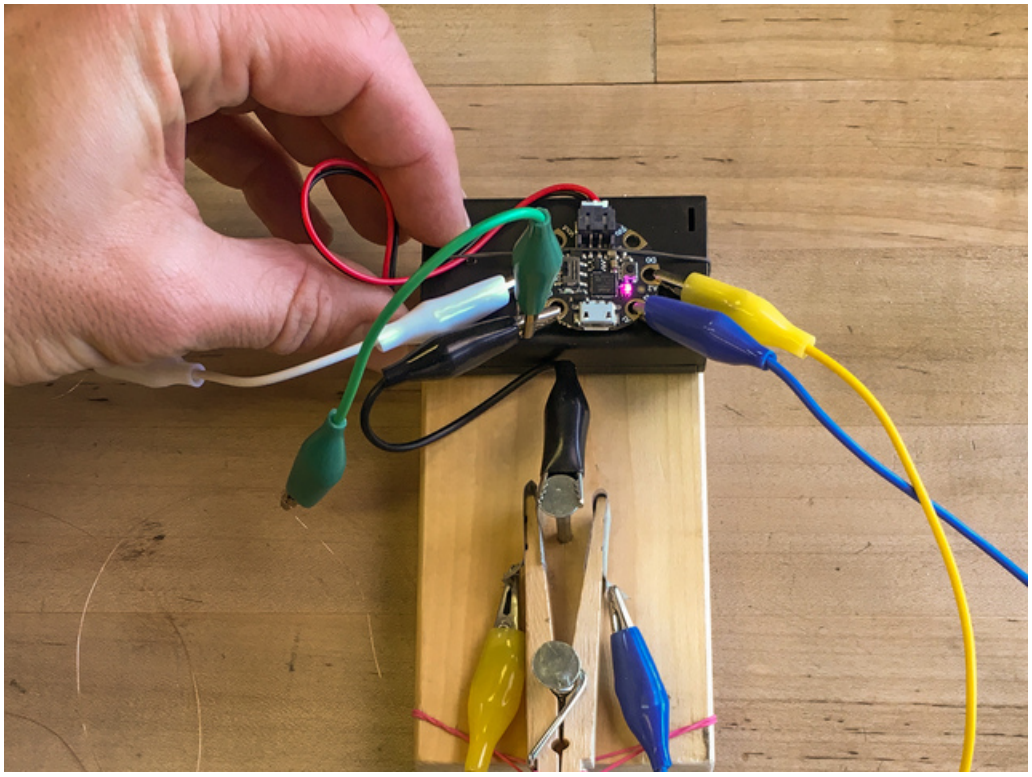


To make the dipole antenna, you'll use two wires instead. Prepare them both as before by scraping off the insulation from one end.

Use alligator clip leads to connect one of the antenna wires to **A0** on the Gemma M0, and the other to **GND.**

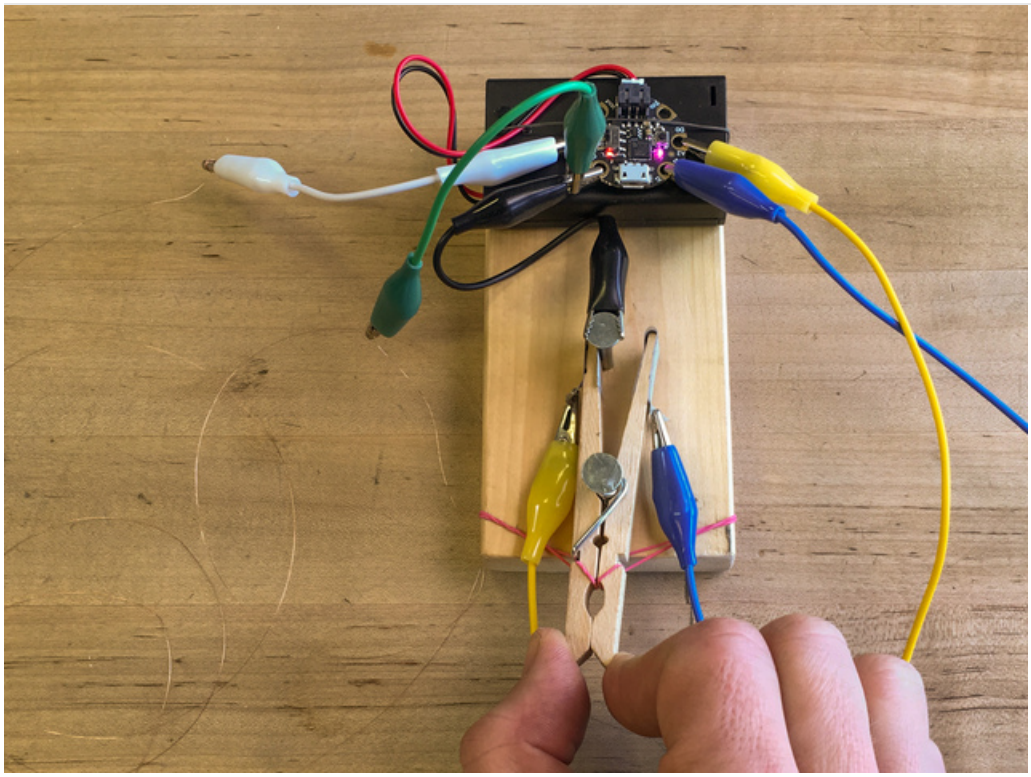




You can try out other arrangements and lengths of antennas to see how the signal strength and noise levels change. What if you orient the antenna differently? What happens if you become part of the antenna by touching the wire?

Next, we'll send some secret messages...

Send Secret Messages



It's time to use your Morse paddle and transmitter to send some messages! Turn on your AM radio, tune it to 540AM, and power up the Gemma M0.

Tap out your secret messages — you could be hidden away in a secret location sending information to an operative nearby with an AM receiver and discrete earphone and nobody will ever know!