Flexible Fabric Lighting Reference Sheet

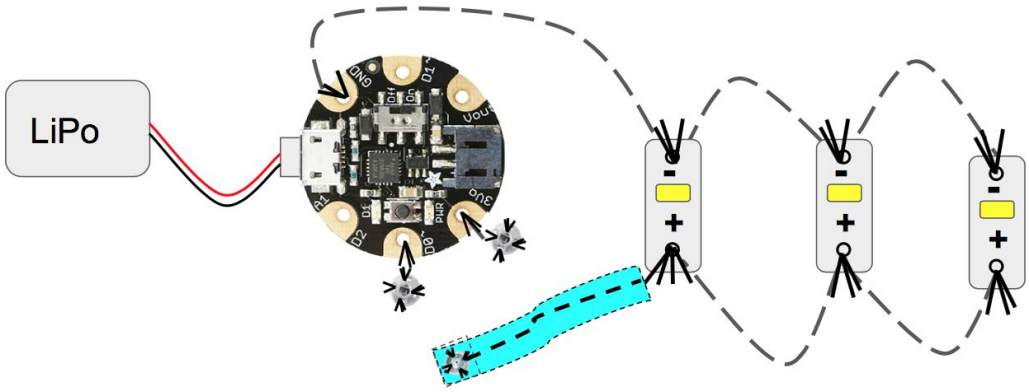
Due to limited time, we will not be able to go deep into the electronics theory that makes this project possible. Our hope is that you will be inspired by this introduction to the world of open source hardware, and will investigate the large universe which lies just beyond what we have shown you today.

Electronics Reference Materials

- https://sciencing.com/advantages-disadvantages-series-parallel-circuits-6306911.html - advantages and disadvantages of series and parallel circuits
- https://www.engineersedge.com/battery/battery_series_parallel_connections.htm - power in series and parallel circuits
- https://learn.sparkfun.com/tutorials/what-is-a-circuit - intro to the components of a circuit
- http://physics.bu.edu/py106/notes/Circuits.html - series and parallel circuits
- https://learn.sparkfun.com/tutorials/lilypad-basics-e-sewing – basic info about how to create a circuit and more tips for working with LED sequins and conductive thread

Directions for Intro to Flexible Fabric Lighting

Introduction



This is the circuit you will be making.

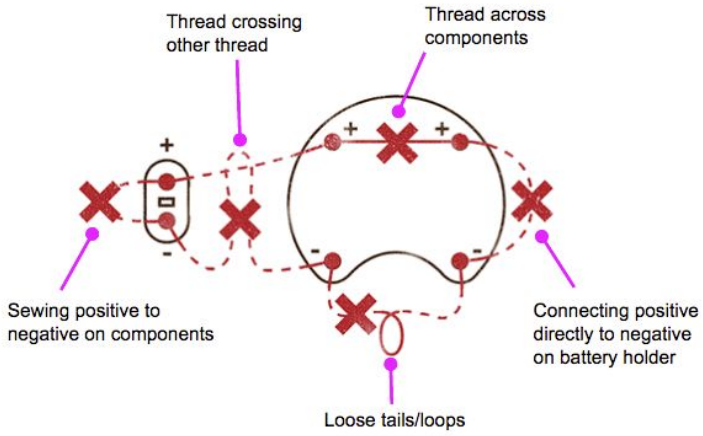
The circuit we'll be making uses conductive thread (which conducts electricity like wire) to connect a Gemma, which is a microcontroller board that can also serve as a "dumb" power pass-through, with three LED sequins, which are designed to be sewn onto fabric. A rechargeable Lithium Polymer (LiPo) battery supplies the power.

We're going to create a "soft switch" (using felt, conductive thread and snaps) in order to change the function of the circuit. When the switch is closed in the 3v0 position, power passes straight from the battery through the Gemma to the LED sequins, then back to GND. When the switch is closed in the D0 position, the Gemma acts as a microcontroller and must have a "sketch" (or instructions or program) loaded in order to work. The three LEDs (which act as if they are a single light source) will be controlled based on the instructions in the sketch.

The LEDs will be connected in parallel, which means that if one LED burns out there are other parallel paths that the electricity can flow through. So even if one of your LEDs is broken, the other two should still light up.

Important Do's & Don't's

- Most importantly: **Do Not Cross The Streams!** Basically, do not let the positive (**+**) trace (trace = thread = leg of circuit) ever cross the negative (**-**) trace. If you do, the circuit will short and things won't work! What does that mean? Don't do this:



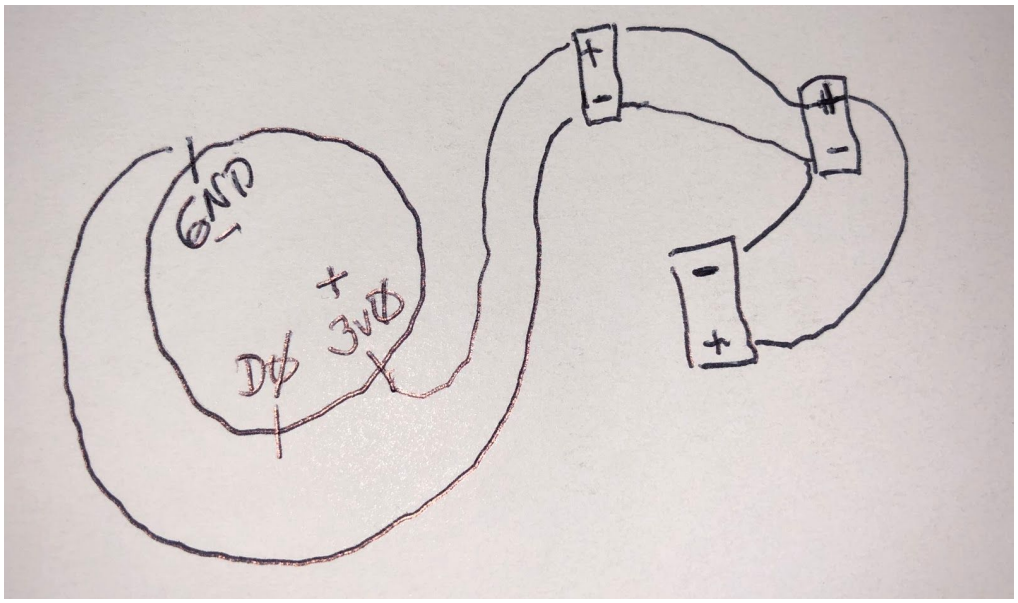
- All the + must be connected (and connected to the 3v0 or D0). All the - must be connected (and connected to GND). Even the LEDs have + and - which makes things easy for you!
- You can't cross a gap – like an a zippered opening – in between two LEDs or between the Gemma and the first LED.

- Any metal can short your circuit – this includes a metal button, a rivet, etc. So avoid those when you are sewing.
- Each time you attach a new component, you'll want to do at least three loops through the component and the fabricUse a relatively short length of thread – no more than an arm's length. Any more than this and everything will get all tangled up.
- Aim to run out of thread at a component, as it makes it easy to knot and start a new piece of thread. If that's not possible, you can just start a new length of thread by knotting it around the old one – remember each trace must be continuous.
- Don't pull your thread too hard! It is easy to snap.

Design

1. Using a sheet of paper, plan the placement of your LEDs & Gemma. Draw each LED (marking + and -) as well as the Gemma.

   Example:



Overall Design considerations:

- Visibility of the LEDs – where will they be seen or be useful?
- Length of conductive thread (you have ~4' to work with for each "trace", or leg of the circuit)
- The closer together the LEDs are, the less sewing there is. We recommend placing all three LEDs in an area smaller than the diameter of a baseball, especially if you are not an experienced sewist.
- The Gemma and battery can go on the inside of the pack, but the LEDs need to go on the outside in order to be seen

- You want to be able to easily reach the switch on the Gemma to turn your lights on and off.
- You want to be able to reach the LiPo battery so that you can remove it to replace it.

These are washable – but you have to remove the battery from the Gemma first.

2. Once you've finished your design, ask one of the instructors to review it with you before proceeding
3. After an instructor has OK'd your plan, use the tailor's chalk or the fabric marker to transfer the design to your bag. Mark and check your traces.
4. Affix your components.

Implementation

Prepping your needle & thread

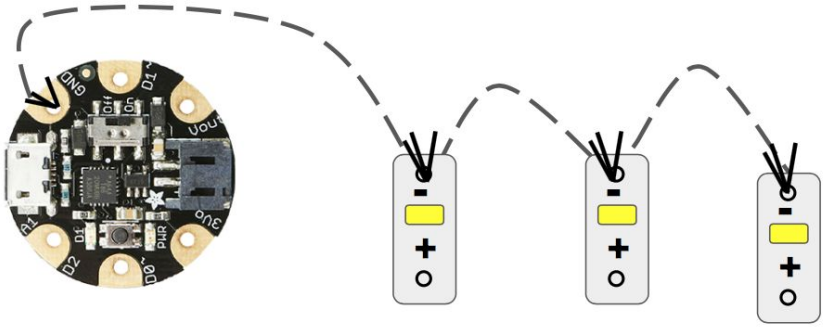
1. Thread the needle. If you're having trouble, try moistening the eye of the needle (not the end of the thread) – surface tension of the water will help "pull" the thread through the needle. Also, try holding the thread still and moving the needle towards it.
2. Do **not** double the thread – leave a tail of 3-4"
3. Make a small knot in the end of the thread opposite the needle.

Connecting the LEDs

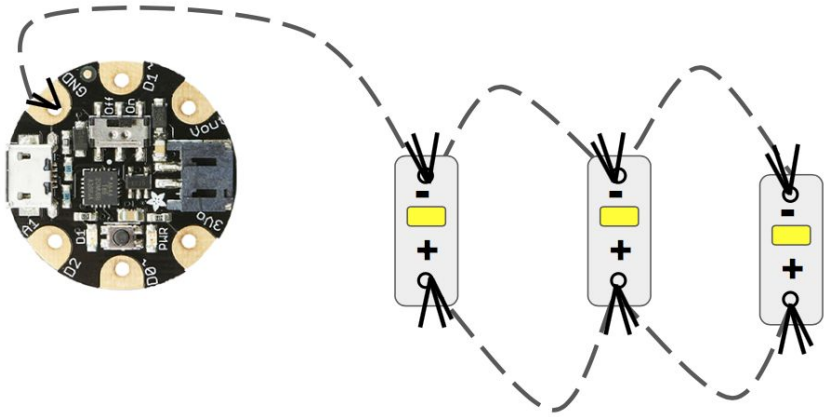
4. Start with a small stitch through the fabric of your clothing to anchor your thread, then pass your needle up through the GND terminal of the Gemma.
5. Go through the terminal and the fabric at least three times, like this:

6. Your first "trace" (or leg) of the circuit starts with the GND terminal on the Gemma then goes to the negative terminal on each of your three LEDs, as shown. Each time you connect an LED, make sure you use three "loops" through the terminal and the fabric beneath.

- Use a running stitch (where you just go in and out of the fabric and you have approximately the same amount of stitching on the “top” and “bottom” of the fabric) to sew over to your first LED.
- Make sure to keep your stitches short and even – we recommend they be no longer that ~.25 (about the width of a ballpoint pen).
- Go around the negative terminal of the first LED and through the fabric (thereby attaching the LED to your fabric) at least three times
- Keep sewing towards the next LED, which you’ll attach to the backpack using at least three loops around the terminal again.



7. Lather, rinse, repeat, until you get to the last LED. After attaching the last LED, knot your thread off, and trim your tail (it can cause a short if you leave a tail dangling!).
8. Tie a new knot in your thread and, starting at the LED that is furthest away from the Gemma, connect the positive terminals of the three LEDs in just the same way as you did the negative trace. When you reach the LED closest to the Gemma, knot the thread and trim the tail. You will have this when you’re done:



Making the Soft Switch

9. Now we’re going to make the “soft switch” – a felt bridge that will allow you to change the way your circuit is connected to the Gemma. Cut a strip of felt that’s roughly .5” longer

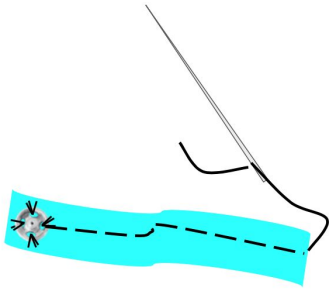
than needed to reach from the positive terminal on the LED closest to your Gemma to the D0 terminal on the Gemma and roughly .5” wide.

10. At one end of the felt strip, use your conductive thread to attach the plug connector part of a snap. As with other components, make sure to go through each hole in the snap at least 2 (and preferably 3) times.

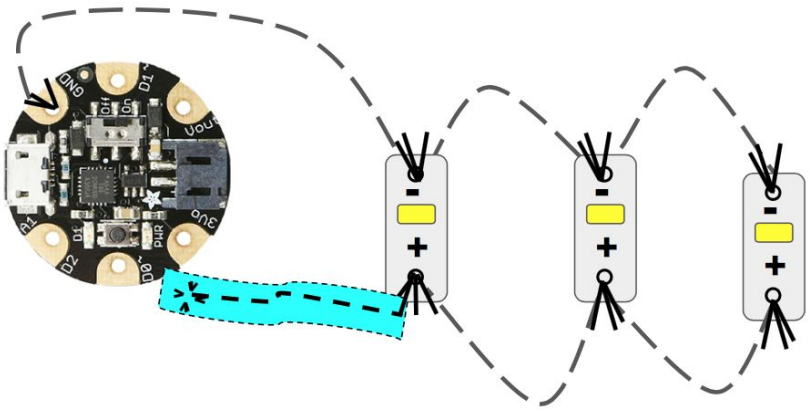
Your felt strip should look something like the image to the left after you’ve attached the snap.

11. Once the snap is firmly attached, continue your line of stitching down to end of the felt strip opposite the snap using a straight running stitch. Remember to keep your stitches no longer than ~¼” or the width of a pencil.

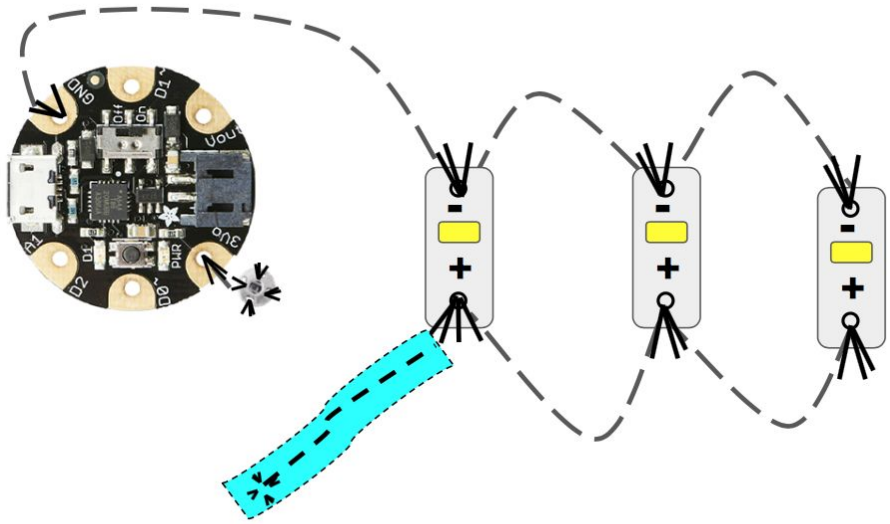
You should end up with this:



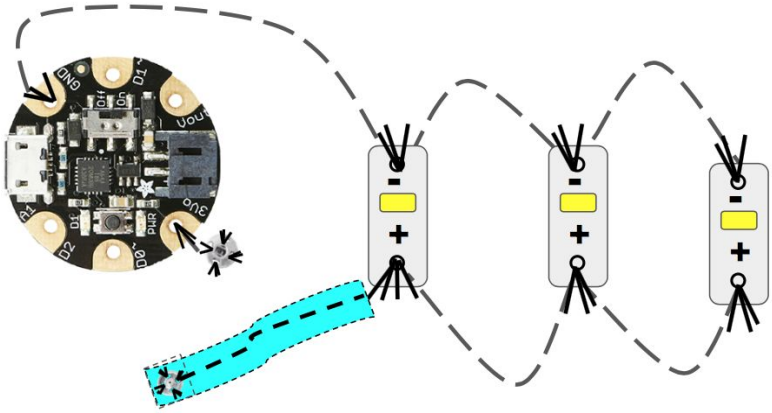
15. Leaving the needle attached, place the felt strip, snap side down, so the end where you’ve just exited the felt with with your needle is close to the positive terminal of the LED closest to the Gemma, like this:



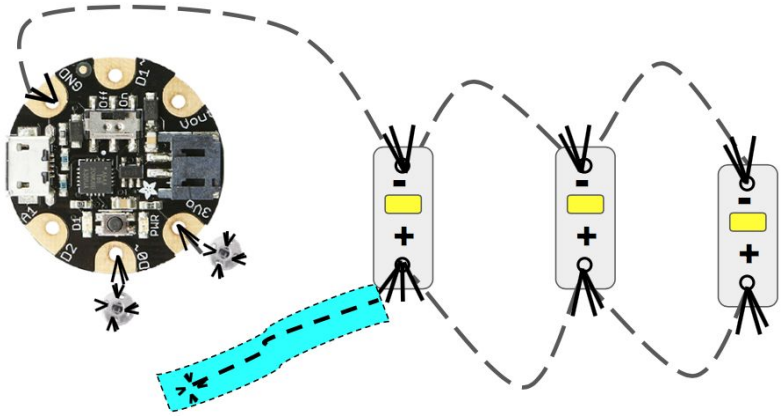
16. Attach the felt strip to the LED and backpack in the same way as you've attached the other components. Use at least 2 stitches, because you want to ensure there's a good connection between the LED and your "soft switch."
17. Attach the socket part of a snap to the backpack very near the 3v0 terminal, which is used to transmit power only. Like you did for the snap on the felt, make sure you go through each hole at least 2 times (and preferably three). You'll have:



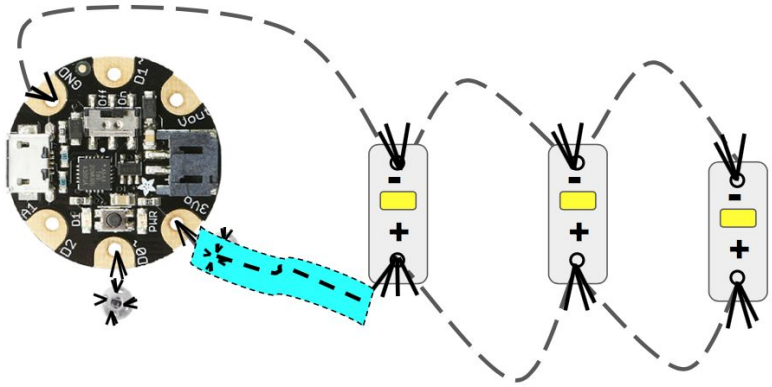
18. Connect the snap you just added to the 3v0 terminal of the Gemma (taking a few short stitches in between if necessary), and once again making sure you take at least three stitches around the connection point on the Gemma:



19. Repeat this process with another socket snap half, this time putting the snap near the D0 terminal of the Gemma, which is a terminal that can send data as well as power.

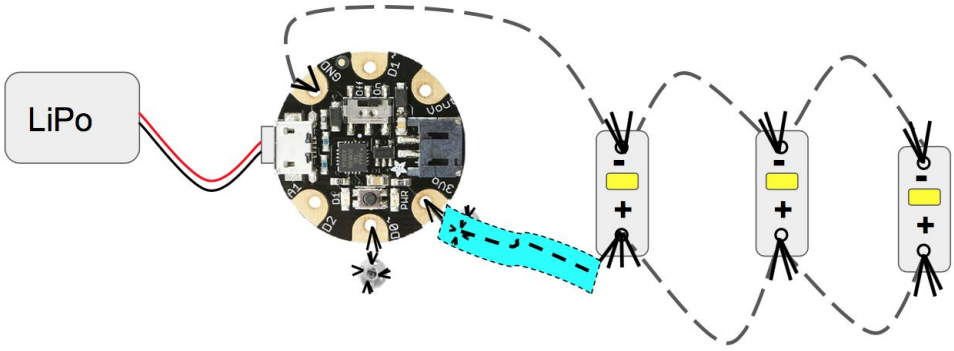


20. Snap the soft switch to the first snap you added, completing the circuit. This connection, the 3v0 terminal, does not require any “instructions” to be loaded on the Gemma (and in fact, it can’t send any – it is only a power pass-through).



Testing

- Time to power your circuit up!
- Make sure the power switch is turned to “off”
- Plug the LiPo battery in (it will only go in one way):



- Flip the power switch “on”

- Lights?
  - If so -- yah!!!
  - If not -- here are some things to troubleshoot
    - **Power - is your battery charged?** Test this by borrowing a “known good” battery.
    - **Do your LEDs work?** You can test this by using a pair of micro-clip leads to connect a CR2032 battery holder (with a battery in it) to each LED in sequence.
      1. Connect one end of one lead to the battery holder’s positive terminal and the other end of the same lead to the positive terminal of the LED.
      2. Connect the negative terminal of the battery holder to the negative terminal on the LED, using opposite ends of the second lead.
      3. Turn the battery switch on.
      4. You should be able to light each LED individually this way (though there are occasionally duds)
    - Do *some* of your LEDs work but each LED can be lit via a 2032 battery pack? Or do your lights work sporadically (they flicker unpredictably)? This usually indicates a short in between the working lights and the non-working lights or a sporadic short. To look for a short, examine the stitching for:
      1. flapping thread tails
      2. loose stitches which may be flexing and coming into contact with other parts of the circuit
      3. Metal in the garment that might be touching the thread: zipper pulls, buttons, grommets, etc. are all likely candidates.
      4. Loose connections at components – you want three tight little loops attaching each component to the fabric.
    - If no lights work at all, make sure that you haven’t “crossed the streams” – that there’s nowhere in the circuit – even at a component - where the positive leg of the circuit can touch the negative one.

Deployment (Final Clean up and launch)

Since you’ve tested the circuit and it is working there are just a few more things to do:

- Make sure the battery pack is secure.
  - If necessary, you can make pocket to support the battery weight with a small square of felt attached to the bag with regular thread or a glue gun.
- Trim all loose threads. Seal any wonky knots with clear nail polish.

- If there is a lot of stitching showing on the outside of the bag, you can use puffy paint to “seal” the stitching lines, protecting them from abrasion and moisture.

Maintenance

This bag requires very little maintenance, though you will need to recharge the LiPo battery periodically!

Before washing, please remove the LiPo battery.

Further Exploration

Your Gemma is pre-programmed by us to have a simple “fade” effect across the LEDs connected to the D0 terminal. Here is a copy of that sketch code:

```
/*
  This example code is in the public domain.
  To upload to your Gemma:
  1) Select the proper board from the Tools->Board Menu (Arduino Gemma if
        teal, Adafruit Gemma if black)
  2) Select the uploader from the Tools->Programmer ("Arduino Gemma" if teal,
   "USBtinyISP" if black Gemma)
  3) Plug in the Gemma into USB, make sure you see the green LED lit
  4) For windows, make sure you install the right Gemma drivers
  5) Press the button on the Gemma/Trinket - verify you see
        the red LED pulse. This means it is ready to receive data
  6) Click the upload button above within 10 seconds
*/

int led = 0;       // blink leds connected to connector 0
int brightness = 0;       // a variable controlling the brightness setting for the LED
int fadeAmount = 5;     // how many points to fade the LED by

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
        analogWrite(led, brightness);
        // change the brightness for next time through the loop:
        brightness = brightness + fadeAmount;
        // reverse the direction of the fading at the ends of the fade:
        if (brightness == 0 || brightness == 255) {
          fadeAmount = -fadeAmount;
        }
        // wait for 30 milliseconds to see the dimming effect
        delay(30);
}
```

Making your own code

You can change the script that is on your Gemma to make the lights blink in different ways. For a good introduction see:

- https://learn.adafruit.com/introducing-gemma/introduction -- explains how the Gemma works and what the different terminals do
- https://learn.adafruit.com/adafruit-arduino-ide-setup/overview -- explains how to set up the Arduino IDE (or programming environment)