# Circuit Samplers

Light Up Zodiac Constellation Sampler Instructions

## What You'll Need

Supplies (standard)

- 6" embroidery hoop
- A tapestry needle
- 8"x 8" square of an opaque, navy fabric such as cotton or a cotton blend
- 8" x 8" square of a navy sheer fabric such as organza or a fine mesh tulle
- Scissors (embroidery or standard will do)
- pins
- Embroidery Thread in the following colors:
    - DMC 117 (Blanc)
    - DMC 823
    - DMC 825
    - DMC 826
    - DMC 827
- A Fabric Marker or pen to mark patterns on fabric
    - IMPORTANT: Do not use graphite pencils, as graphite is conductive and could break your circuit. Fabric pencil is fine to use here.)

optional:

- Fabric Glue, Elmer's Glue or nail polish for sealing in ends

Supplies (specialty)

- 1 Bobbin Conductive Thread
    - https://www.sparkfun.com/products/10867
- 5 Sewable LEDS
    - https://www.sparkfun.com/products/13902
- 1 Sewable Battery holder
    - https://www.sparkfun.com/products/13883
- 1 Coin Cell Battery (20mm CR2032)
    - https://www.sparkfun.com/products/338
    - (LIR2032 option) https://www.amazon.com/dp/B07L933KGQ/

# Understanding Circuits

## Understanding Electricity

**Electricity** is the flow of electrical energy in one direction through a conductive material.

You might remember from high school science that atoms are made up of neutral particles (Neutrons), positively charged particles (Protons) and negatively charged particles (Electrons). Because Protons and Neutrons are both significantly heavier than electrons, they can't move from atom to atom, so when we talk about the flow of electricity, we're talking about the movement of electrons between atoms.

## Understanding Circuits

A **circuit** is a closed loop containing a source of electrical energy (our 3V **battery**) and a **load** (our **LEDs**) which converts the energy to another form, such as light, heat, or motion. In a working circuit, all the energy from the power source will be used up by the loads. If the power in a circuit is *not* used up, it's a **short circuit**.
In a **short circuit**, the electrical energy will flow back to its source, which can cause irreversible damage to your battery*

### Helpful Terms

Here are some terms it's helpful to understand when talking about electricity:

**Conductors** are materials like metals which allow for a free flow of electricity.
Some examples of common conductive materials:

- Copper wire
- Aluminum foil
- Steel Wool
- Water
- Conductive Thread: the thread we will use in this project is made of finely spun steel, which means it's great at conducting an electrical current.

**Current** is the term we use to refer to the amount of electricity flowing through a conductive material.

**Voltage** is the “push” behind an electrical current. For instance, in this project we’re using a 3 Volt battery, so that’s the measurement of the amount of electricity being pushed through our circuit and getting converted into light energy by the LEDs.

**Insulators** are materials that do not allow electricity to flow through them. Good examples of insulating materials are:

- Glass
- Plastic
- Rubber

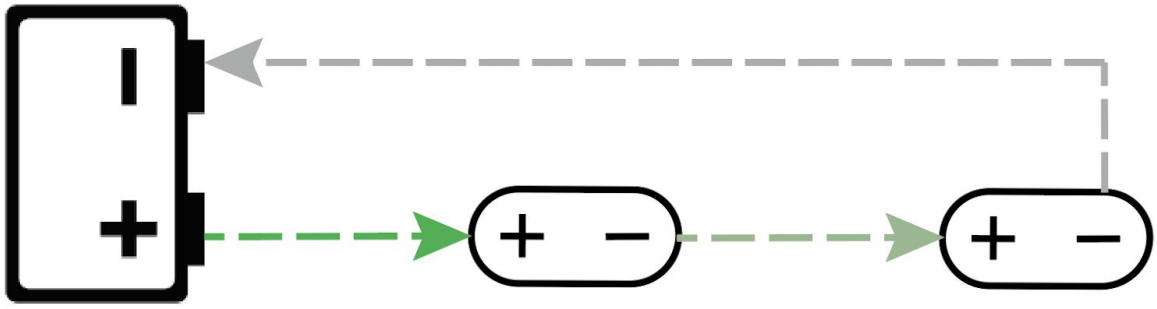
In regular electronic circuits, wires are usually coated with plastic to protect the user and prevent the loss of current. The conductive thread we’re using does *not* have any protective coating but that’s okay! Why?

- We’re working with a very low voltage, so any electricity you come into contact with won’t be strong enough to hurt you.
- There will likely be a slight loss of current over the circuit, but since the electricity only needs to travel a few inches, it will be minimal enough that it won’t affect the circuit.

**Resistors** slow down, but don’t totally block the flow of electricity. Some of the electricity is able to move through this material, but the current will be reduced as the energy moves through this material. The reason this is useful, is that components that receive too much current for them to convert into other energy, they’ll start converting electricity to heat, and then they’ll burn out (or worse, explode!)  If we were building normal electronics circuits, we’d have to include resistors but one of the great features of sewable LEDs is they have tiny resistors built in, so that step is done for us!

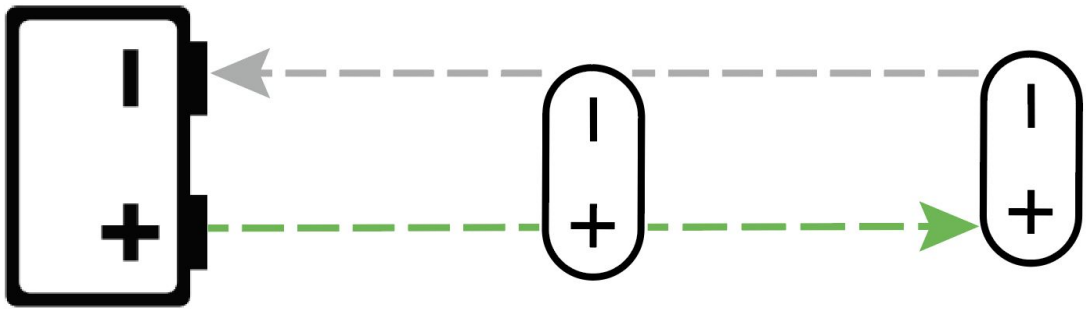
## Series vs. Parallel

There are two ways to power LEDs in a circuit, and they behave in different ways. The first way we’ll look at is in series:



When you connect LEDs together in a single line like this, it's called "in series". What happens in this kind of a circuit is that the full range of power flows through one LED at a time, and the LED takes the full amount of power it can possibly convert into light before passing current on to the next light. The drawback here, is that if your power source doesn't have enough voltage, the lights further out in your circuit won't be as bright.

The form of circuit we'll be using in this project is called "In parallel" and the circuit will look something like this:



When you sew LEDs together in a circuit like this, the power flows evenly through all the LEDs before returning to ground on your power source.

As a result, even if the lights glow more dimly, they will all glow evenly. (An added perk of sewing lights in parallel is that if one light goes out, the others stay working)

# Techniques for Sewing with Conductive Thread

While most of the techniques of sewing with conductive thread are the same as any thread, there are a few ground rules  and challenges you'll need to remember when working with conductive thread.

### Texture

Conductive thread is made of spun steel, so the texture of this fiber is not what you're used to. The texture is a lot stiffer, there's more friction, and it's more likely to fray and tangle. Err on the side of shorter pieces of thread to avoid tangles in your circuit.

### Always Double Down

Because we want to make as clear a pathway for our current as possible, it's best to double up the thread to make a thicker path for the electricity to move through.

For the same reason, you want to use as much thread as possible when connecting battery or LED components, so that there's a nice solid amount of surface area to connect the pieces of your circuit. I find a good general rule of thumb is to loop around each sew tab at least 3 times when making connections.

### Knots and Glue

Because this material makes up the path the electricity will travel, this means you need to alter some of the "usual" ways you might handle thread, especially on the back of your sampler.

As a rule, you never want to weave conductive thread behind other stitches on the back of your sampler!

Try starting your circuit with a quilters knot, and when you reach the end of a connection, finish by tying a knot around the loops you made around your sew tab.

Once you're done stitching, you'll want to isolate any end pieces of fabric and glue them down (somewhere where they don't contact other pieces) either with a small dab of elmers or fabric glue or a drop of clear nail polish.

### Protect your battery

While you're sewing, it's really easy to touch thread to other parts of your circuit and accidentally create a short circuit.

ALWAYS take your battery out when you're working, and only pop it in when you're ready to test the circuit. It's a light enough charge that you won't hurt yourself either way, but a short circuit could kill your battery.

# Start Stitching

Okay! Now that we've covered the basics, let's get started. Choose the astrological sign you want to stitch from pages 9-32, and refer to the instructions below!

## Layer 1: Circuit Stitching

This first pattern layer represents the stitching for your circuit. The larger circle is your battery holder, and the small pill-shaped shapes are your sewable LEDs. Take a look at these components in real life - you'll see that they're all marked with tiny (+) and (-) symbols. These will be your guides to making sure you're connecting everything correctly. The electrical current will flow from the + connection points back around to the - connection points on the battery.

1. **Set up your Hoop** - This step is the same as what you're already used to, Take the **Opaque Navy Fabric** and secure it in your embroidery hoop so that it's pulled taut.
2. **Copy the Pattern** - Using a pen or fabric pencil (DO NOT use graphite here! Graphite is conductive and could break your circuit) mark out the placement for your components and stitch lines.
3. **Connect Your Battery to the BACK of your sampler**. If you want to, you can secure the battery holder in place with a drop of glue before you start sewing.
4. **Start sewing connections**
    a. Using two strands of conductive thread, loop around either of the two (+) sew tabs that you see on the battery in the diagram. Make sure to loop through the hole on the battery pack at least 3 times.
    b. Using a running stitch, sew a straight connection to the first LED in the diagram, and connect it by looping around the (+) sew tab at least 3 times.
    c. Continue from this (+) sew tab, and stitch another straight running stitch to the next LED. Again, loop around the sew tab 3 times.
    d. Once you've reached the end of this line of LEDs, secure your connection with a small knot, and make sure neither loose thread ends are touching any other parts of the circuit.
5. **Repeat**. Take a new length of conductive thread and connect the (-) sew tab of the battery in line with the (-) sew tabs on the LEDs. Don't forget to loop around each connection a minimum of three times.

6. **Test**. Once you've finished securing your connections, it's time to test this half of the circuit! Place a coin cell battery in your battery holder, and flip the switch to "on". Are all your lights working? If not, try checking for these common errors:
    a. Are your connections secure? Is the conductive thread laying flat on the metal portion of the sew tab?
    b. Are your (+) and (-) connections properly lined up? Have you sewn any LEDs in facing the wrong direction?
    c. Are any pieces of thread hanging loose? They could be touching other parts of the circuit and causing a short.
    d. Is your battery fully charged? Make sure you only place a battery in the holder when you're ready to test. If you accidentally short the circuit while working, you can fry your battery and will need to replace it.
7. **REPEAT Steps3-6** on the other side of your circuit!
8. Secure any stray ends of conductive thread with a small dab of glue. (I like using tacky glue, but any kind of craft, fabric, or elmer's will work. You can even use a small dab of clear nail polish if you prefer.

## Layer 2: Regular Embroidery

1. Remove your circuit from the hoop and place your sheer fabric in the hoop.
2. Use a pen or fabric pencil to mark the pattern onto your fabric (be careful not to press too hard, as some sheer fabric can have a tendency to warp.
3. **Black** Being careful to stitch over your ends so that they don't show through the fabric, use a long and short stitch and your white thread to make the outline of your LED stars.The smaller circle should be the open circle around the Led, and the larger circle marks the length of your longer stitches.
4. **Grey** Fill these areas in with a raised satin stitch. The circle stars should be white, and the Astrological sign should be DMC 827.
5. Remove the fabric from your hoop and place it on top of your circuit fabric. Carefully line up your LEDs with your stitched star-holes, and pin the fabric in place. (Make sure your battery is not in the holder, so the pins won't break your circuit!)
6. Place both pieces of fabric, pinned together, back into your hoop. Carefully remove the pins.
7. **Blue** With DMC 827, sew these lines through both pieces of fabric using a split stitch. Be careful not to stitch through any pieces of conductive thread!
8. Trim your fabric and glue the ends to the interior edge of your hoop, being careful not to obstruct access to your battery holder.