Conductive Heater Fabric

This is a non-woven conductive fabric that feels a bit like thick paper or thin craft foam. With an electrical resistance of 20 ohms/square inch, it will heat up when current is applied. It is lightweight, very flexible, and can be easily cut with regular scissors. Perfect for wearables!

For full technical information and specifications, check out the product page (https://adafruit.it/CkC). In this guide we'll look at some ways to connect to the fabric, how to control it with code, and some ideas for projects.

Because you will be working with heat and more experimental circuitry, this type of project is best suited for intermediate makers. Before working with this material, you should be comfortable with basic electronics concepts and safety.

The visual examples in this guide use cotton fabric treated with heat-reactive paint on top of the conductive fabric to show heated areas. The conductive heater fabric itself does not change color!
Materials

Here are the materials I used for the experiments in this guide:

- EeonTex High-Conductivity Heater Fabric (https://adafruit.it/CkC)
- Adafruit Metro M0 Express (https://adafruit.it/xoa)
- Sewable Snaps and Eyelets (https://adafruit.it/CkD)
- TIP120 Darlington Power Transistors (https://adafruit.it/CkE)
- Alligator Clips (https://adafruit.it/CkF)
- Power Supply (https://adafruit.it/eny) and Female Screw Terminal Adapter (https://adafruit.it/CkG)
- Cotton Broadcloth
- Thermochromic Pigment (I used these (https://adafruit.it/CkK))
- Textile Medium or ModPodge
Placement

When placing your connections, keep in mind that the flow of current through the material will dictate how the fabric heats up. The heat will be concentrated at the sources of current and radiate along its path and outward. You can see this in the examples below, where I experimented with connection placement.

Always use caution when working with exposed metal connections and heat. Turn off power to your circuit before moving connections or making changes.

For these tests, I used a 5” square of conductive heater fabric and connected a 12V power supply using alligator clips. I placed a piece of cotton broadcloth painted with thermo-reactive fabric paint on top of the heater fabric. The blue areas in each image show the heated areas.
2 Connections on the Same Side

2 Connections on Opposite Sides

Two Connections Across Corner

Four Connections on Opposite Sides

Four Connections Across Corners

Keep in mind:

1. The distance between your power and ground wires matters - if they are too close you will get a very hot spot that could smoke/burn, and if they are too far apart the heat will concentrate around each connection point.

2. If you decide to connect power and ground in multiple places along the piece of fabric, the distance between each set of power and ground connections must be consistent. If one set of connections is closer together, the heat will concentrate between them.
Connections

Alligator clips are fine for experiments, but if you're building an actual project you'll want something more secure. Here are two methods of connecting power to the conductive fabric: rivets and snaps.

The rivet option is very secure, while the snap option allows for rotating or removing the wires after installation. Both methods delivered current to the fabric reasonably well, but results were varied, and you'll need to do some tests to choose a method that works for your specific project.

These techniques are based on the research and methods documented by Kobakant at their website, How To Get What You Want (https://adafru.it/CkN). Check out their Hard/Soft Connections (https://adafru.it/CkP) for more ideas and techniques!

**Warning:** Metal connections can get hot! Always work on a protected surface and be extra careful when working with exposed metal connections.

Snaps

To use snaps, solder your wire to the back of the stud (the "innie" side of the snap). Then punch a small hole in the heater fabric and thread the post (the "outie" side of the snap) through the hole. Snap the post and the stud together, sandwiching the heater fabric.
Eyelets

For conductivity, make sure you’re using bare metal eyelets, do not use eyelets that are coated or painted. Start by bending the stripped end of the wire into a hook shape. Small jewelry pliers can be helpful here.

Press the hook around the post of the eyelet. Punch a hole in the conductive fabric and feed the eyelet into the hole. Crimp with eyelet pliers to secure, catching the wire inside the rim of the eyelet.
To use the conductive heater fabric with a microcontroller like Metro M0 Express, you'll need to use a transistor to control the flow of current in your circuit. The Metro can tell the transistor when to let current flow and when to stop it.

To learn more about transistors, check out this section (https://adafruit.it/CkQ) from Simon Monk's great guide on using Arduino to control a motor.

If this is your first time with Metro M0 Express, be sure to visit the Metro M0 Express Guide (https://adafruit.it/xAW) to learn everything you need to know and get set up for programming!
Circuit

Here is a simple circuit for using the heater fabric with an Adafruit Metro M0. The Metro is powered by USB. Power from the 12V power supply goes directly to the heater fabric, but the ground goes to the collector of the transistor. The emitter of the transistor connects to the fabric. The base pin of the transistor is connected to pin 10 on the Metro M0 Express.

An LED is connected to pin 2, for visible feedback that the button code is working. As always, place a resistor on the positive leg of the LED. For more further testing, you could add an LED further downstream in the circuit, to show that the fabric is receiving current.

The Metro M0 Express connections are:

<table>
<thead>
<tr>
<th>GND</th>
<th>Ground on LED, button, and emitter pin of transistor. Also connect to ground of battery/power supply.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 10</td>
<td>Base pin of transistor</td>
</tr>
<tr>
<td>Pin 9</td>
<td>Connect to LED - Place a resistor between this pin and the positive leg of the LED</td>
</tr>
<tr>
<td>Pin 2</td>
<td>Connect to button - one side of the button goes to this pin, the other side goes to ground</td>
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</tbody>
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Code

This code, written in Circuit Python, controls the flow of current to the fabric through the transistor connected to data pin 10. When we set the pin to high, the fabric will heat up. When the pin is set to low, the current will stop flowing to the fabric, and it will slowly start to cool down.

Pressing a button connected to data pin 2 illuminates the LED and sends current to the fabric, heating it up. Releasing the button stops the flow of current.
import time
from digitalio import DigitalInOut, Direction, Pull
import board

# Set up the transistor on Pin 10, name it "base", and make it an output.
base = DigitalInOut(board.D10)
base.direction = Direction.OUTPUT

# Set up the LED on Pin 9, name it "led", and make it an output.
led = DigitalInOut(board.D9)
led.direction = Direction.OUTPUT

# Set up the button on Pin 2, name it "switch", and make it an input. Enable the pull up resistor on the pin.
switch = DigitalInOut(board.D2)
switch.direction = Direction.INPUT
switch.pull = Pull.UP

while True:
    if switch.value:
        base.value = False
        led.value = False
    else:
        base.value = True
        led.value = True

    time.sleep(0.01)  # debounce delay
Play With Heat Changing Color

This material is well suited for wearables, cosplay, and e-textiles, and more. One exciting way to see the heat spread across your conductive fabric is with heat-reactive paint!

Thermochromic pigments change color when exposed to temperature changes. Pigments come with different temperature ratings, for this application you'll want to look for pigments that are static at room temperature and change when heat is applied (as opposed to cold).

For all of the examples in this guide, I used heat activated 86F pigment from Solar Color Dust (https://adafru.it/CkK). The pigment can be mixed with textile medium or ModPodge. If your textile medium is thin, you'll be able to mix in more pigment for denser color without making your fabric too stiff. Experiment with ratios until you get the effect you want.
After painting your fabric with the thermo-reactive paint, let the fabric dry completely before applying heat to see the color change. In some cases, the pigments can get "stuck" on one color if you apply too much heat while they are drying. If you want to cut down drying time, use a fan to blow cool air over the painted fabric.
There are some awesome projects out there using heating circuits and heat-reactive paint. Check out the projects below for inspiration!

Heat Changing Tutu (https://adafruit.it/CkT) by Lynsey Calder
Thermochromic Projects on Instructables (https://adafruit.it/CkW)
Thermochromic Projects on Hackaday (https://adafruit.it/CkY)