

Knitting With Conductive Yarn

Knitting is a really versatile and flexible way to integrate sensors and other conductive material directly into fabric. Depending on the kind of pattern, and the type of yarn that you use, knitted textiles can be used to integrate directly into stretchable, conformable fabric:

- stretch sensors
- touch sensors
- switches
- pressure sensors

At the CCI we have a range of conductive yarns and threads that can be used that have variable conductive and textural properties. We have a Silver Reed knitting machine that is suitable for knitting 2-3ply yarn, and can be used programmatically with the DesignaKnit software.



Typically, the conductive yarn is used along with a *carrier yarn*, that adds structural stability, colour, and texture to the knit.

In general, knitted textiles should not be used to conduct any current greater than 100mA or so, as they can risk getting hot, and because of their form (and the potential for shorts) in general my advice would be to consider them primarily as sensing rather than conductive material.

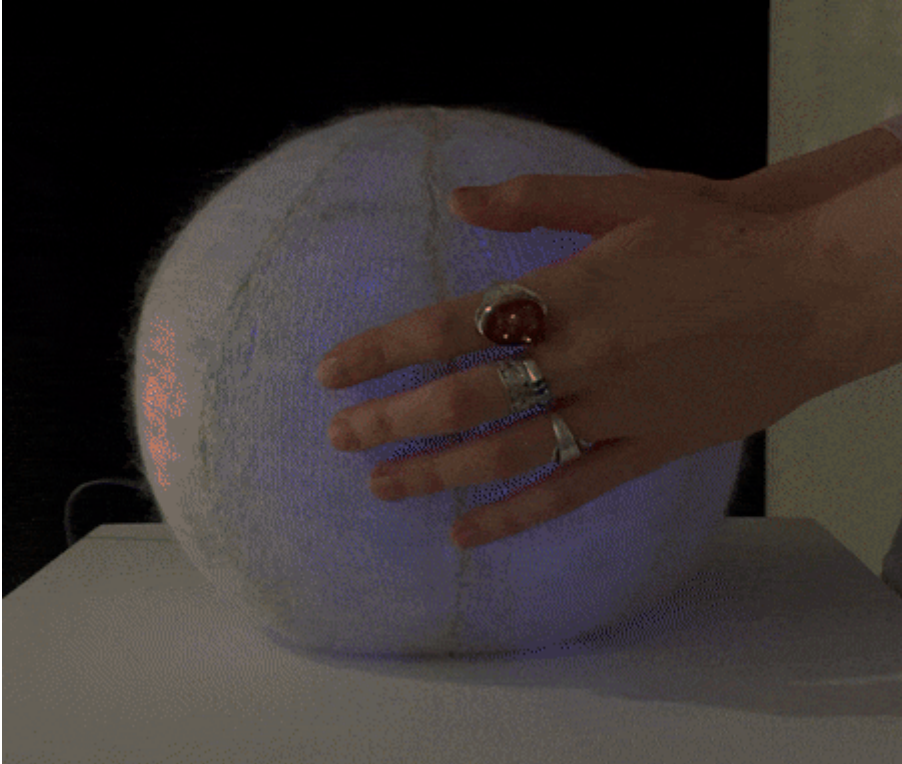
This page isn't a tutorial on the Silver Reed (please email Agnes if you would like one), but an overview of options for making conductive knitted textiles at the CCI.



Knitted Touch Sensor

It's possible to use conductive knits along with the [MPR121 Capacitive Touch Sensor](#). This allows you to detect when a conductive object has been touched. Often, you might need to adjust the sensitivity of the MPR121 to pick up on the signals from the knit sample, as these can be much less strong than more conductive media like copper tape.

e-textiles support technician Rosie Walker made a touch-sensitive orb using an intarsia technique to make sure the samples weren't touching!



In order to get the sensor to work properly, she both changed the thresholds of the MPR121, and used a set of buffers to smooth the signal.

Adjusting the Sensitivity of the MPR121

To initialise the MPR121, the following lines are needed:

```
Adafruit_MPR121 cap = Adafruit_MPR121();

void setup(){
  cap.begin(0x5A);
}
```

This `begin()` function is defined as follows:

```
begin(uint8_t i2caddr=MPR121_I2CADDR_DEFAULT,
      TwoWire *theWire=&Wire,
      uint8_t touchThreshold=MPR121_TOUCH_THRESHOLD_DEFAULT,
```

```
uint8_t releaseThreshold=MPR121_RELEASE_THRESHOLD_DEFAULT)
```

By default the values are `MPR121_TOUCH_THRESHOLD_DEFAULT = 0x41` and `MPR121_RELEASE_THRESHOLD_DEFAULT = 0x42`. The `0x` at the beginning of the number shows that they are written in hexadecimal, click [here](#) to understand how hexadecimal works and to convert between hexadecimal and decimal.

We can change these values to adjust the sensitivity. To do this, add arguments to `begin()` with new values for the thresholds, as below:

```
Adafruit_MPR121 cap = Adafruit_MPR121();

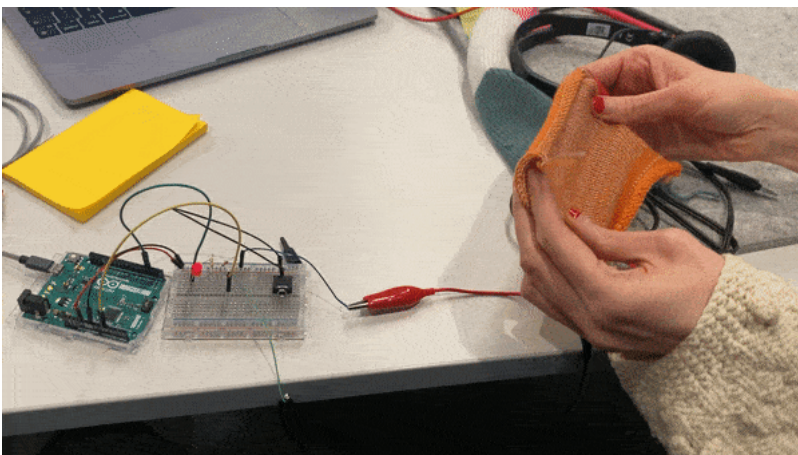
void setup(){
  cap.begin(0x5A, &Wire, 0x4, 0x5);
}
```

To see the full definitions for the MPR121 Arduino library, click [here](#)

Knitted Stretch Sensor

Knitted fabrics that integrate conductive yarn will have different amounts of resistance, depending on the size of the sample, the density of the stitches, and the yarns used. These samples can be used as part of a [voltage divider](#) circuit, which measures a changing resistance.

In the circuit below, the knitted stretch sensor is being used to control the brightness of an LED:



These sensors can be used anywhere a potentiometer would be used instead. Typically the signal is much noisier and harder to control, but you can still get some interesting results! One example project is the [knitted synthesisers workshop](#).

Measuring the Resistance



When trialling knit stretch sensors, it's important to know the range of resistances you are working with. You can measure their resistance using a multimeter

Attach the crocodile clips to the edge of the sample, and connect the other ends to the multimeter. Move the wheel of the multimeter to the setting with the Ω symbol, and press the 'mode' button until you also see a Ω on the screen.



Once the system is connected, you should see a reading of the sample's resistance on the multimeter. Try stretching the sample and the number should decrease! Note that the letters next

to Ω refer to the magnitude: k stands for 'kilo' ($\times 1000$), and M stands for 'mega' ($\times 10,000$). You want your sample to be at least a few $k\Omega$ for this to work.

Knitted Switch

By bringing pieces of conductive knit into contact with one another, or with other conductive things (like a wire!), it's possible to toggle the state of a circuit on and off. One sample switch in the CCI is a knit sample where the conductive yarn is integrated in stripes!

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