

Data as a Material?

Making a Sensor



```
solemaker.js
```

```
function redraw() {
  var voronoiCells = voronoiCellsGroup.selectAll(".voronoi-cell")
    .data(voronoi_polygons(voronoi_points))
    .enter()
    .append("path")
    .attr("class","voronoi-cell")
    .call(redrawPolygon);

  voronoiCells.call(redrawPolygon);
  voronoiCells.exit().remove();

  voronoiCellsGroup.selectAll(".voronoi-cell")
    .call(redrawPolygon);

  /**
   * Convert the outline points and voronoi seeds to sole fields
   */
  // Check if outline_points is round
  if(outline_points.length > 2) {
    var sole_polys = generate_cells_without_outline_inset(outline_points, voronoi_points, voronoi, sole_design);
    sole_cells = sole_polys;
    voronoi_cells = generate_cells_without_outline_inset(outline_points, voronoi_points, voronoi, sole_design);
    // var sliced_cells = slice_polygons(sole_polys);

    var sole_poly_selection = soleCellsGroup.selectAll(".sole-cell")
      .data(sole_polys, function(d) { return d; });

    sole_poly_selection
      .enter()
      .append("path")
      .attr("class","sole-cell")
      .attr("d", function(d) { return d ? "M" + d.join("L") + "Z" : null; });

    sole_poly_selection.attr("d", function(d) { return d ? "M" + d.join("L") + "Z" : null; });
    sole_poly_selection.exit().remove();
  }

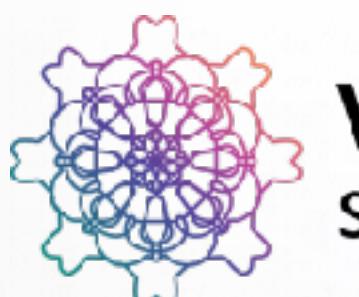
  var outline_circle = pointControlsGroup.selectAll(".outline-circle")
    .data(outline_points);
}

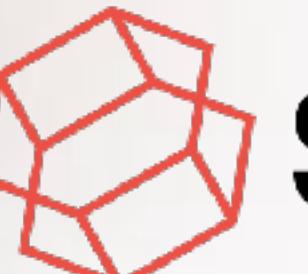
Line 1, Column 1
```

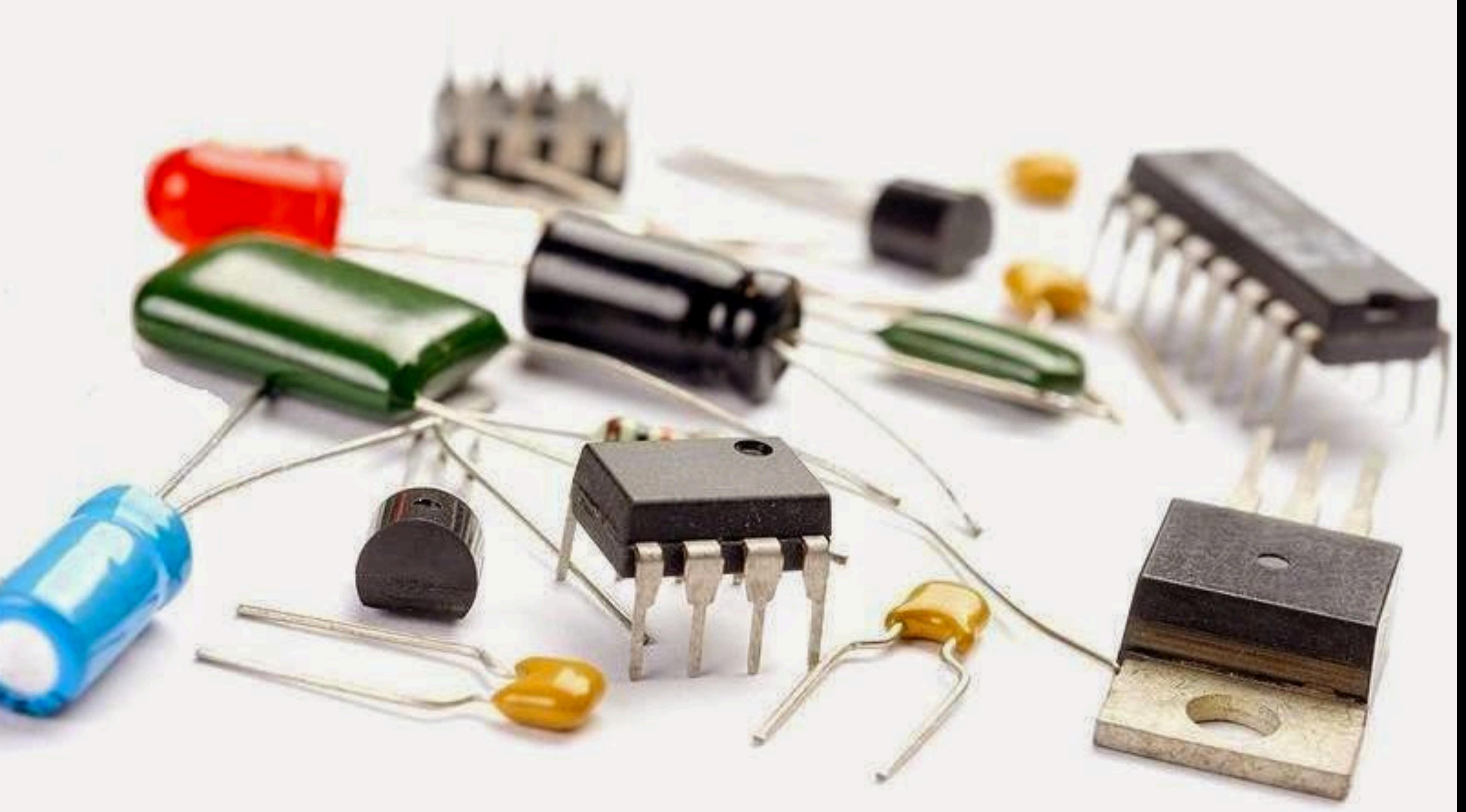
Tab Size: 4 JavaScript

ArcInTexETN
Marie Skłodowska-Curie actions European Training Network (ETN)



 **WEAR**
sustain

 **Solemaker**



arduino.cc

The screenshot shows the Arduino website ([arduino.cc](https://www.arduino.cc)) displayed in a web browser. The page features a dark teal header bar with the Arduino logo and navigation links for PROFESSIONAL, EDUCATION, STORE, HARDWARE, SOFTWARE, CLOUD, DOCUMENTATION, COMMUNITY, BLOG, and ABOUT. Below the header, there's a large "WHAT IS ARDUINO?" section with an image of an Arduino Uno board and buttons for "BUY AN ARDUINO" (with a shopping cart icon) and "LEARN ARDUINO" (with a bell icon). To the right, a red-bordered box highlights "ARDUINO EDUVISION" with a callout for the "LATEST" episode, featuring a cartoon robot and a screwdriver. Another section encourages users to "Make your experience greater, explore new products!" by checking out Robotis' products. At the bottom, there are links for "ARDUINO IN THE CLOUD" (with a cloud icon), "BLOG" (with a yellow elephant icon), and "Help". The browser's toolbar and address bar are visible at the top.

WHAT IS ARDUINO?

ARDUINO EDUVISION

LATEST

Did you miss the last episode?

No worries! Click here to watch it now!

BUY AN ARDUINO

LEARN ARDUINO

DONATE

ARDUINO IN THE CLOUD

Make your experience greater, explore new products!

Take a look on Robotis' product range now on the store!

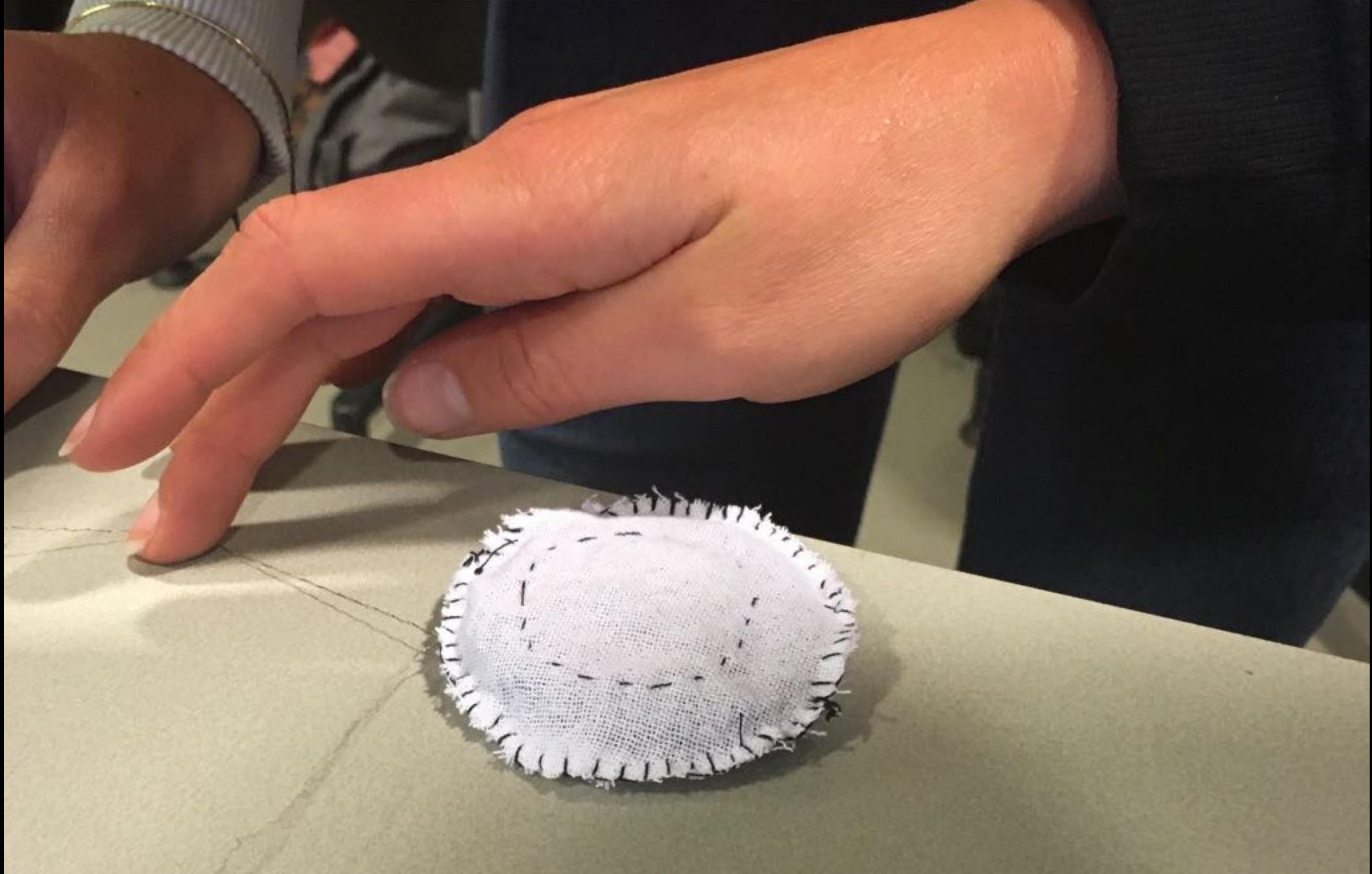
Check it out now!

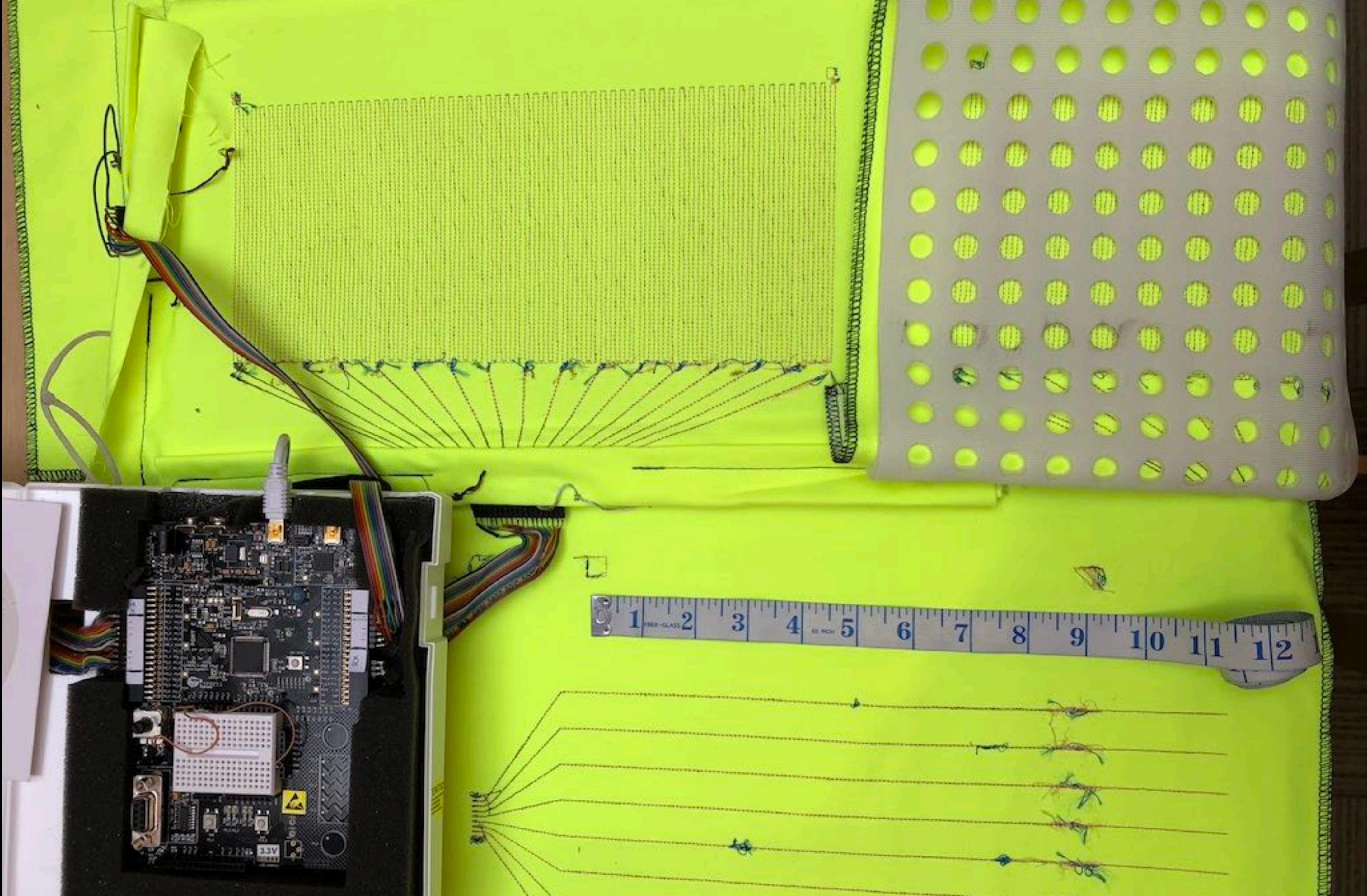
BLOG

Help

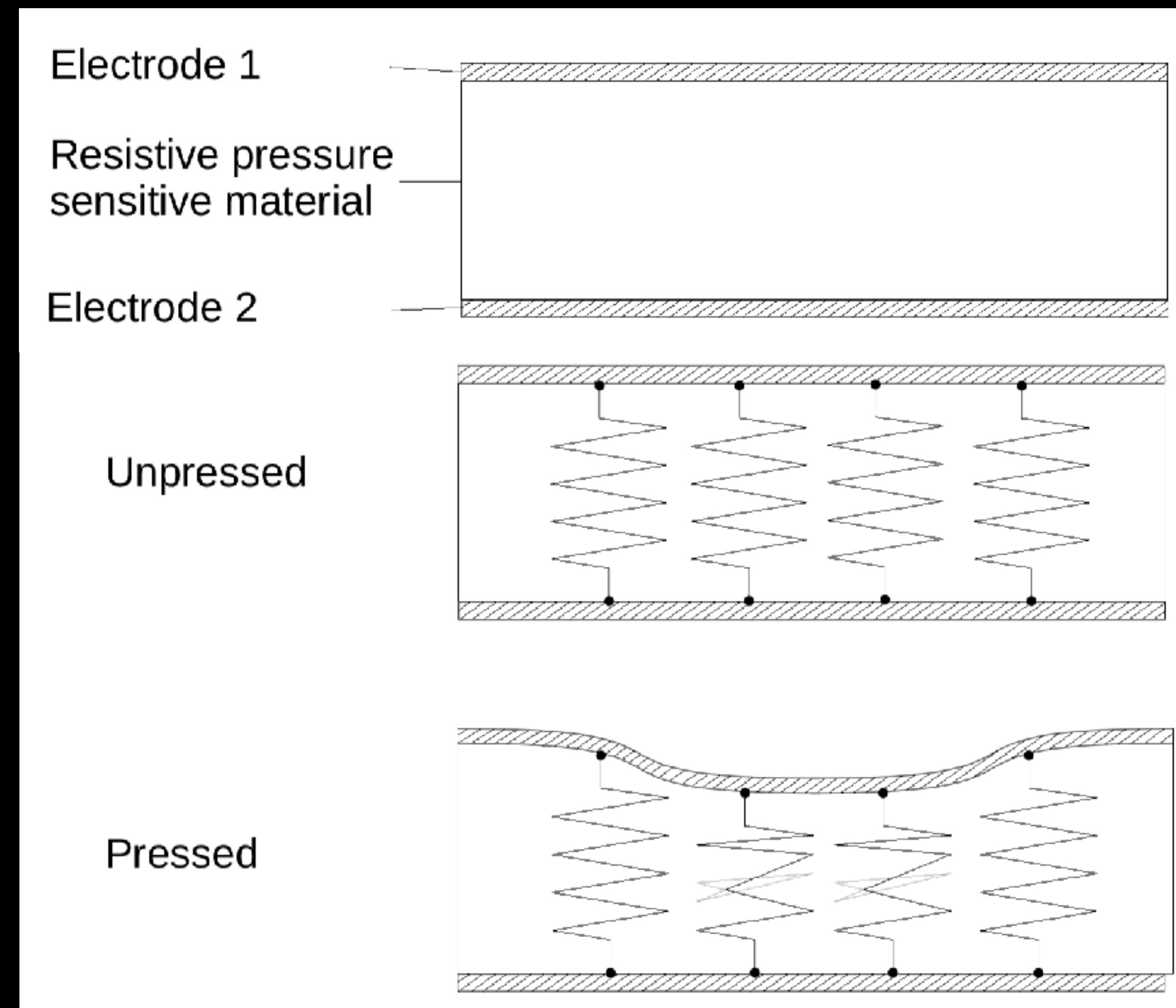


Soft Sensors



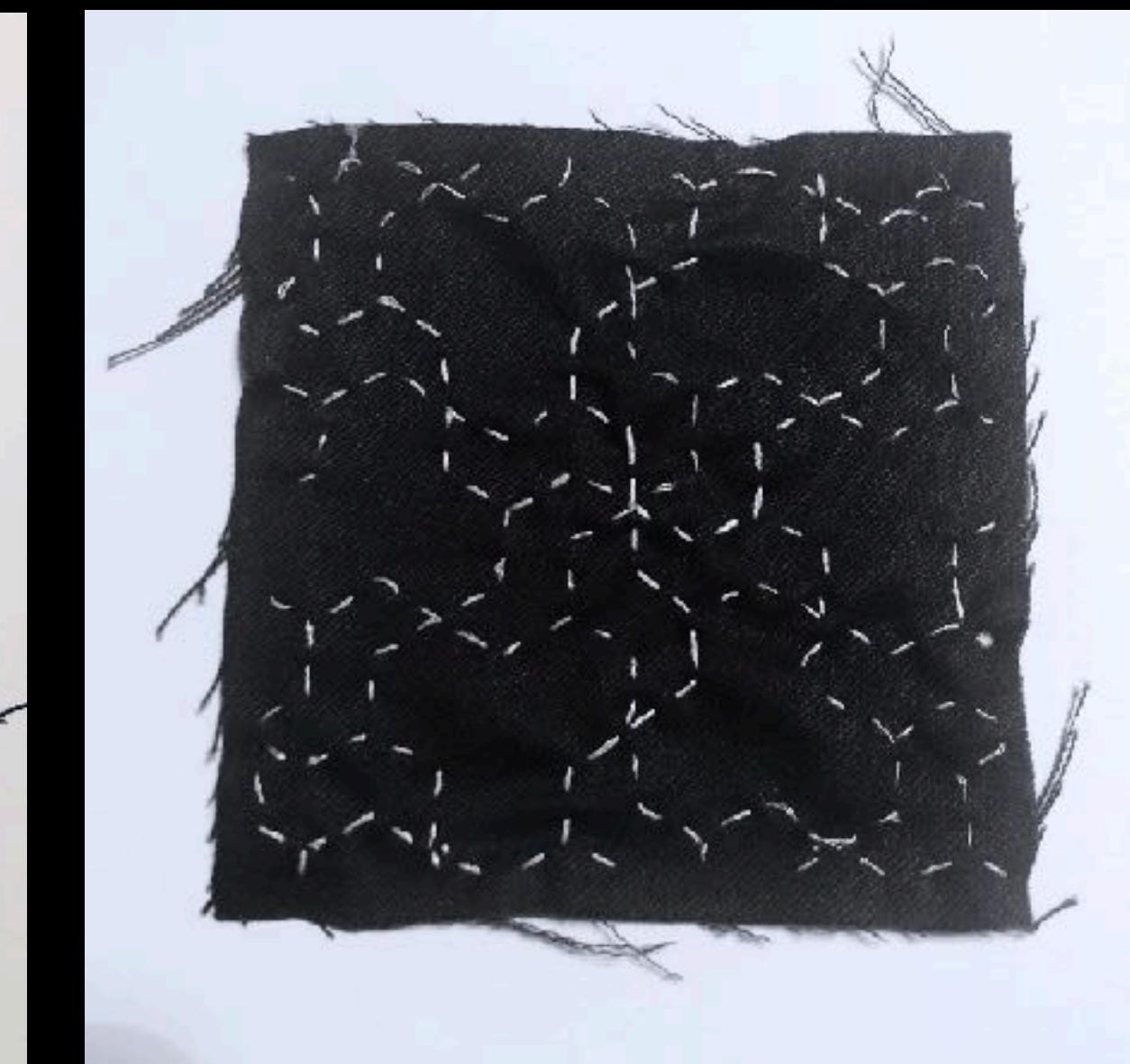
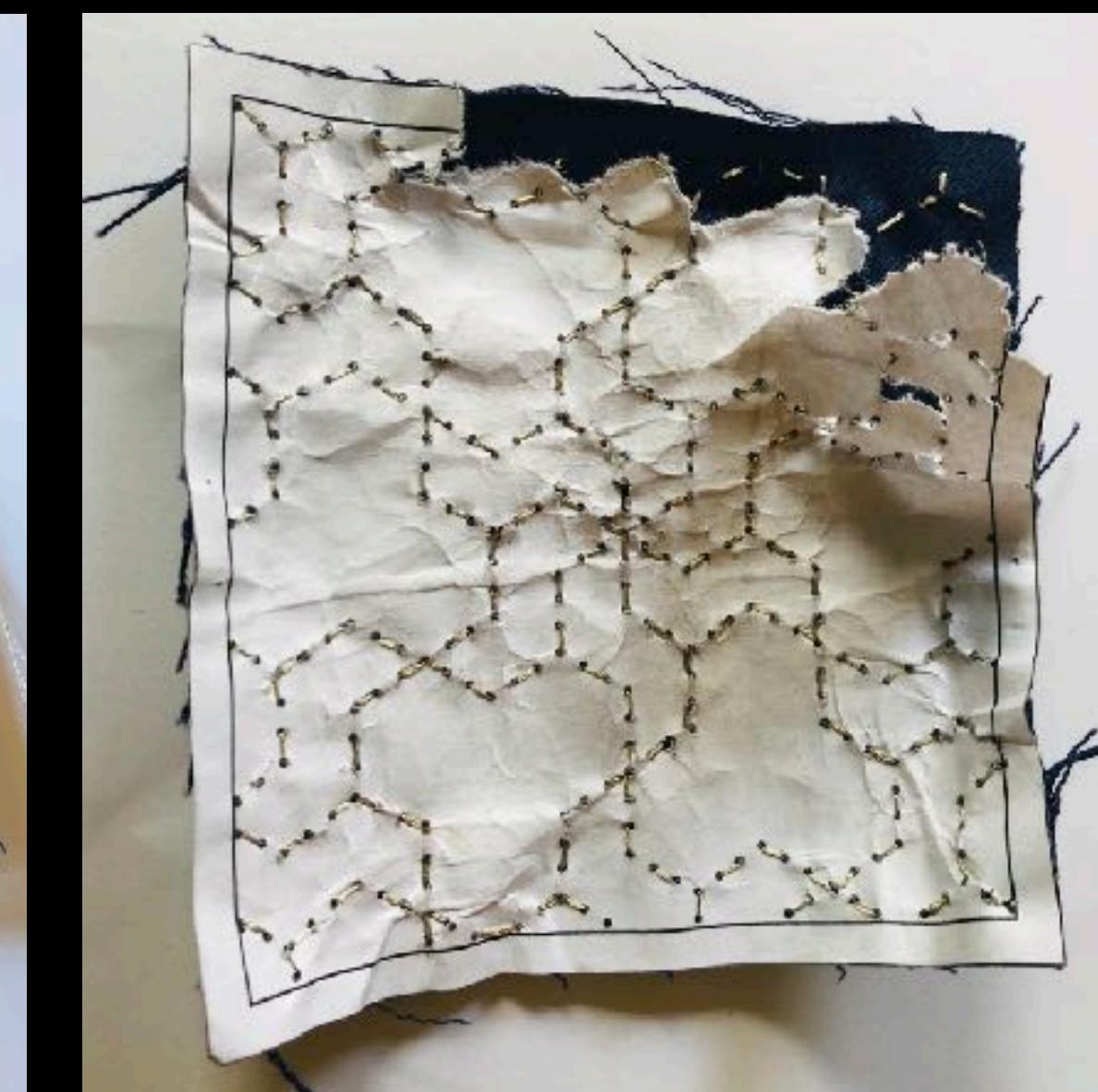
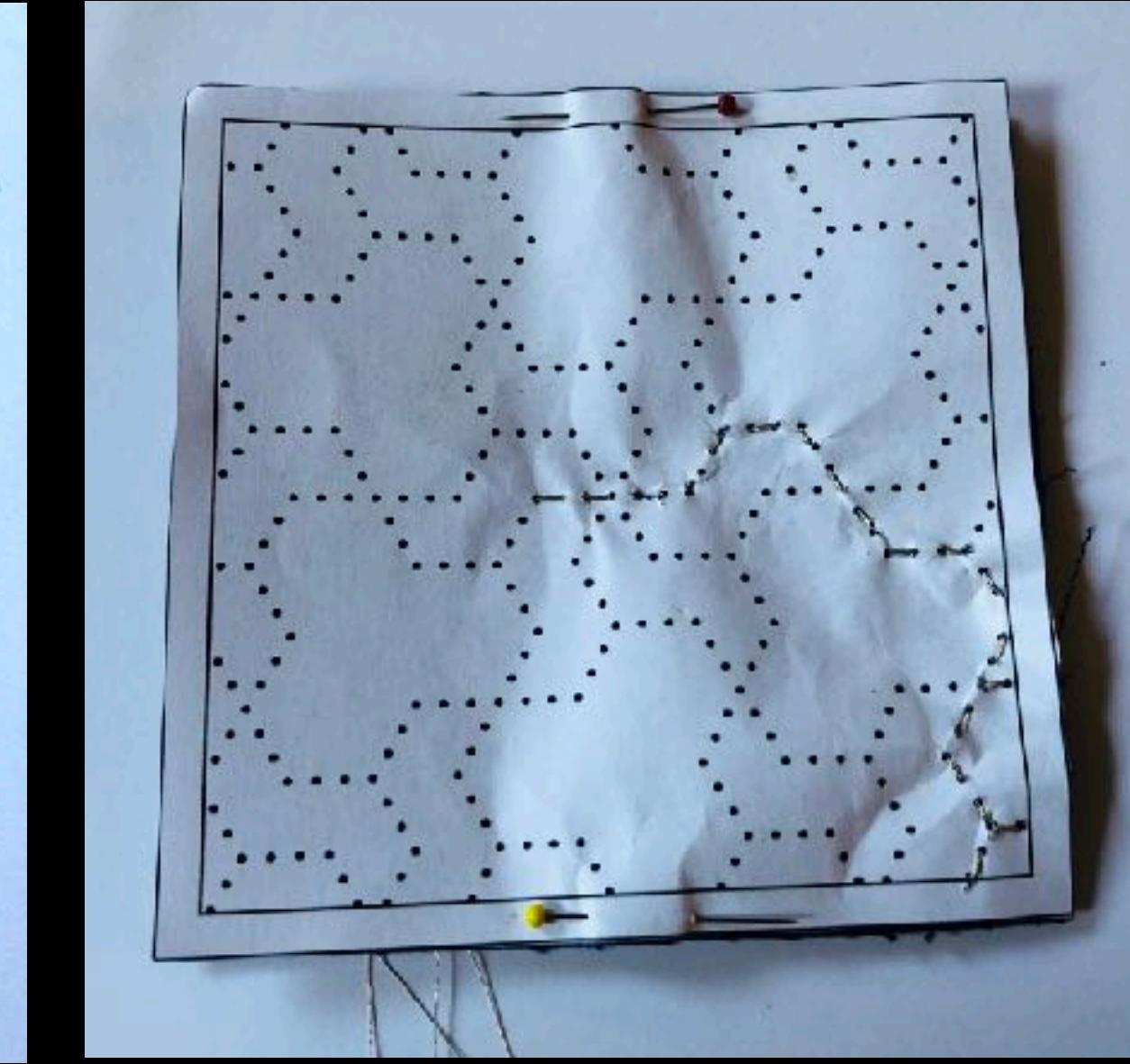
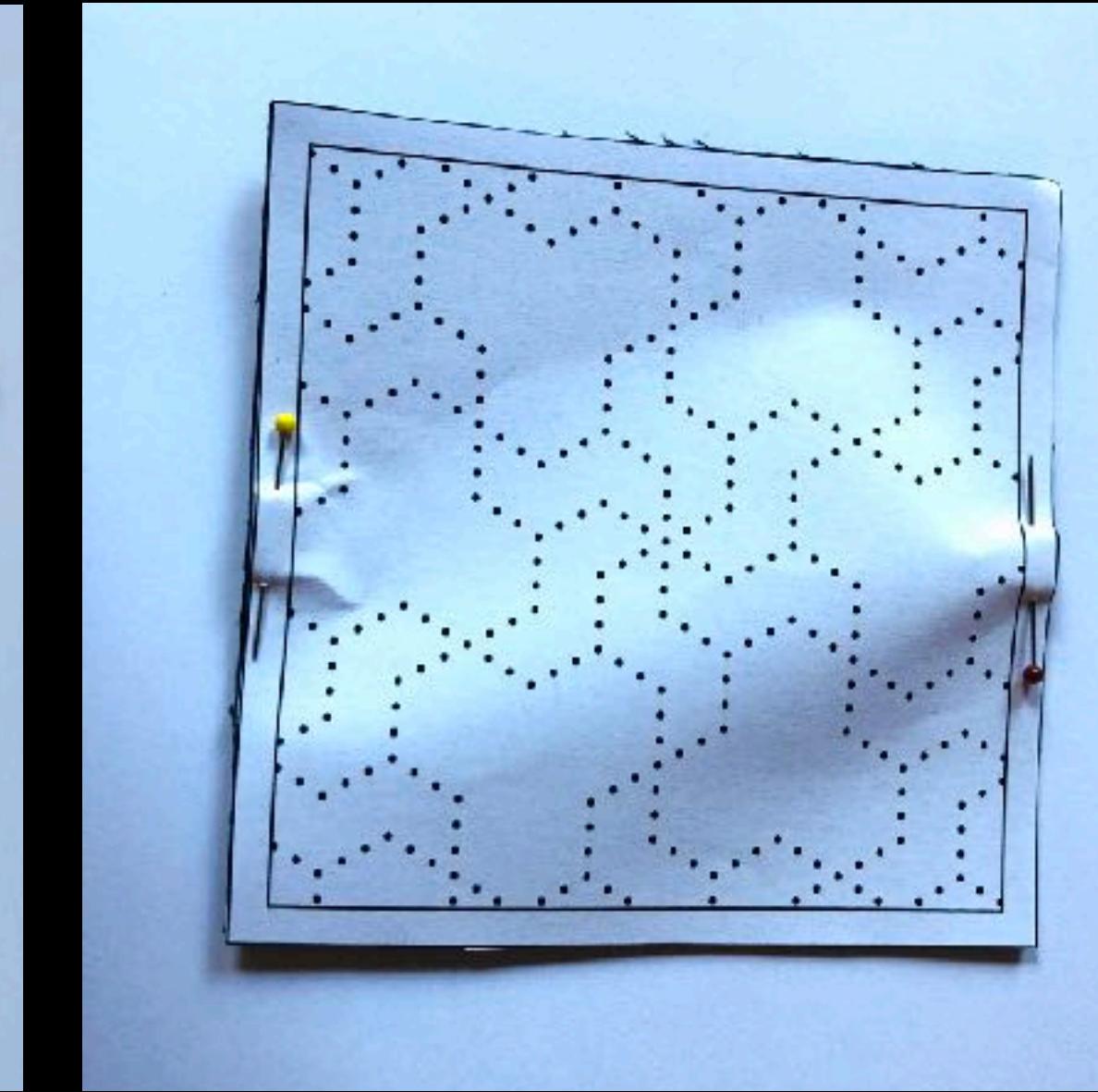
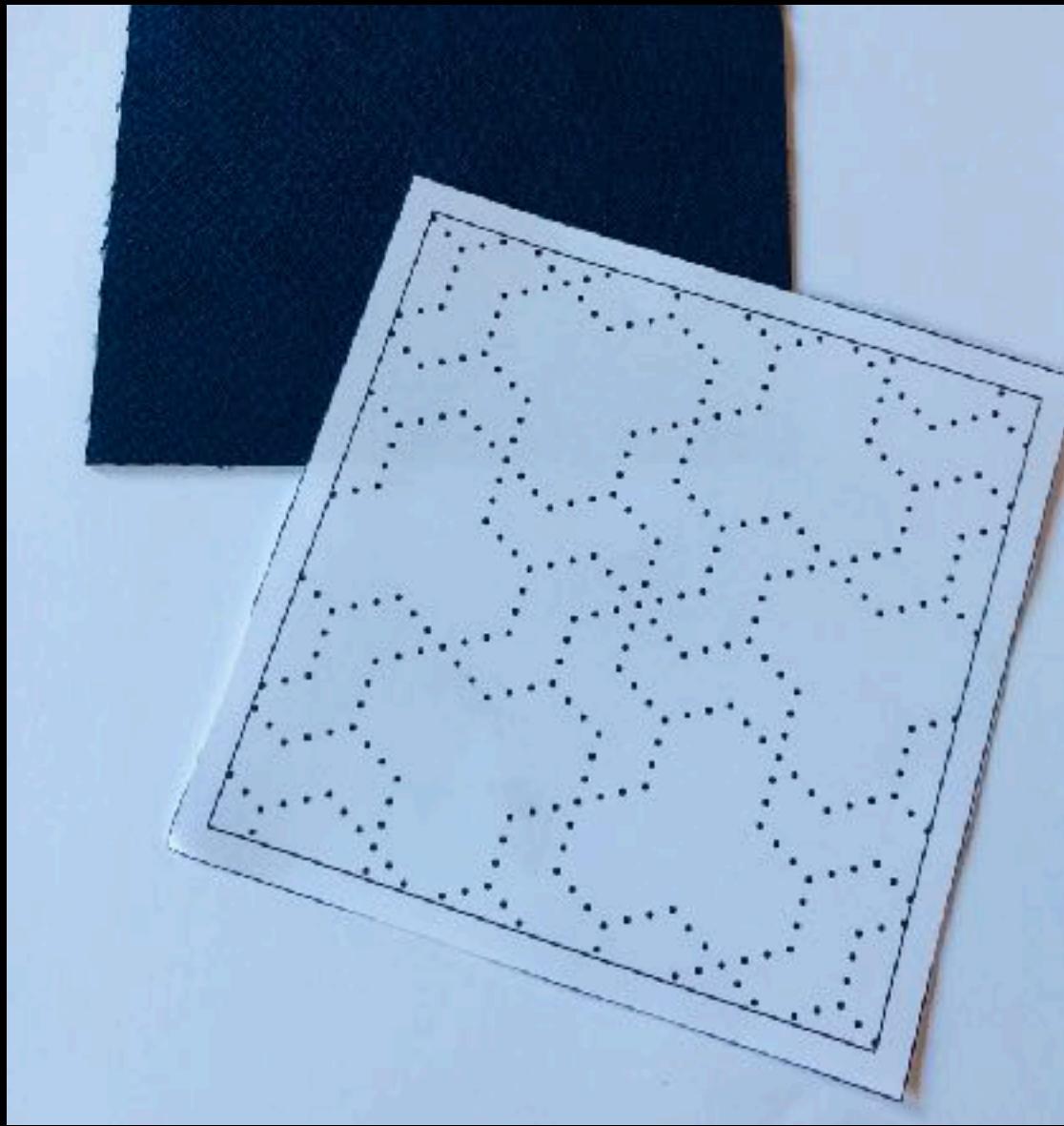


Sandwich Sensor





“Sashiko”



What's in the Middle

Pressure sensitive material: Velostat

Velostat / Linqstat

image: aura-comms.com

- PE film
- Impregnated with carbon based material
- Typically about 0.2 mm thick
- Slightly compressible

Different types of Velostat:

- High resistivity (50 kOhm/sq – 200 kOhm/sq)
- Medium resistivity (1 kOhm/sq – 50 kOhm/sq)
 - Useful for large pressure sensors
- Low resistivity (< 1 kOhm/sq)
 - Useful for pressure sensors



← DO NOT USE THIS

← USE THIS

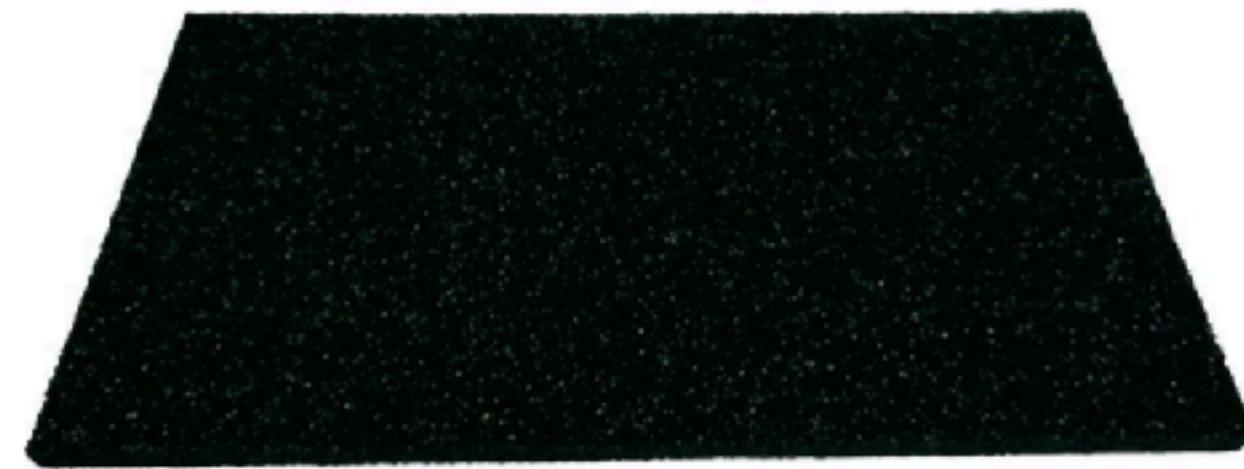
← OR USE THIS

Pressure sensitive material: foam

ESD foam

image: conrad.com

- Low density PU foam
- Impregnated with flexible conductive latex (carbon based)
- Typically about 5 mm thick
- Very compressible

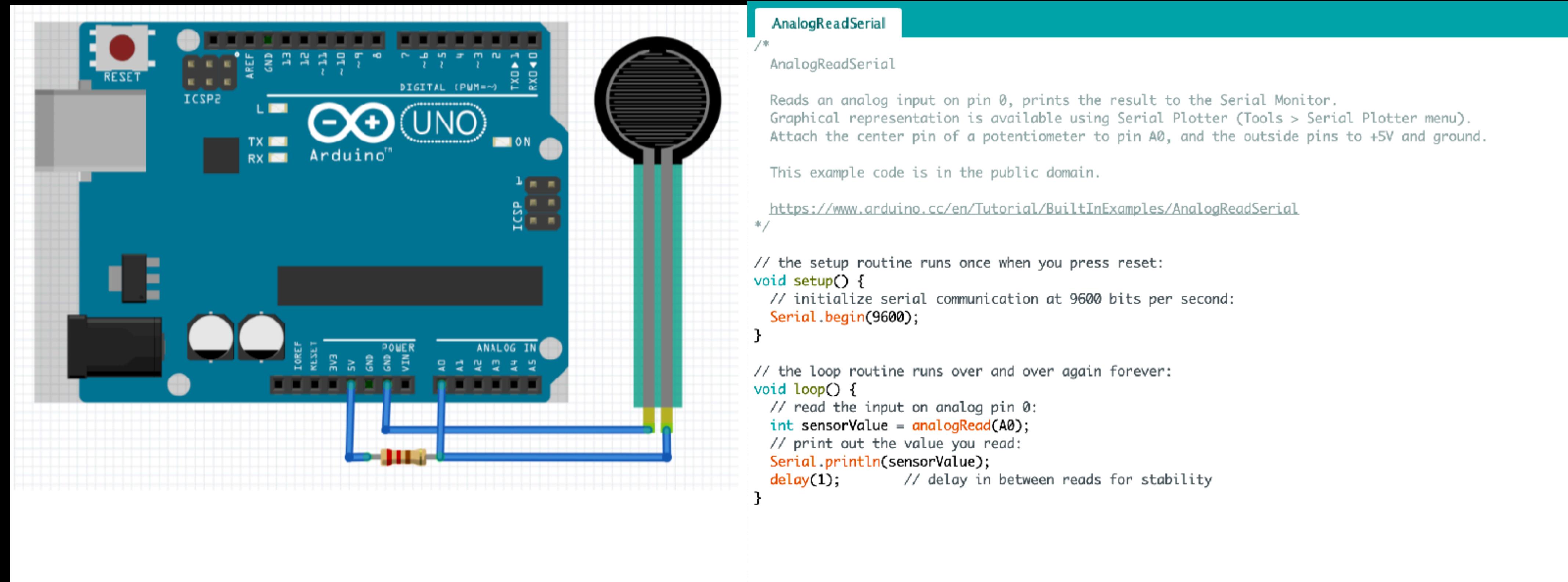


Different types of ESD foam:

- Stiff, not very compressible foam ← DO NOT USE THIS
- High resistivity ← DO NOT USE THIS
- Flexible, medium / low resistivity ← USE THIS

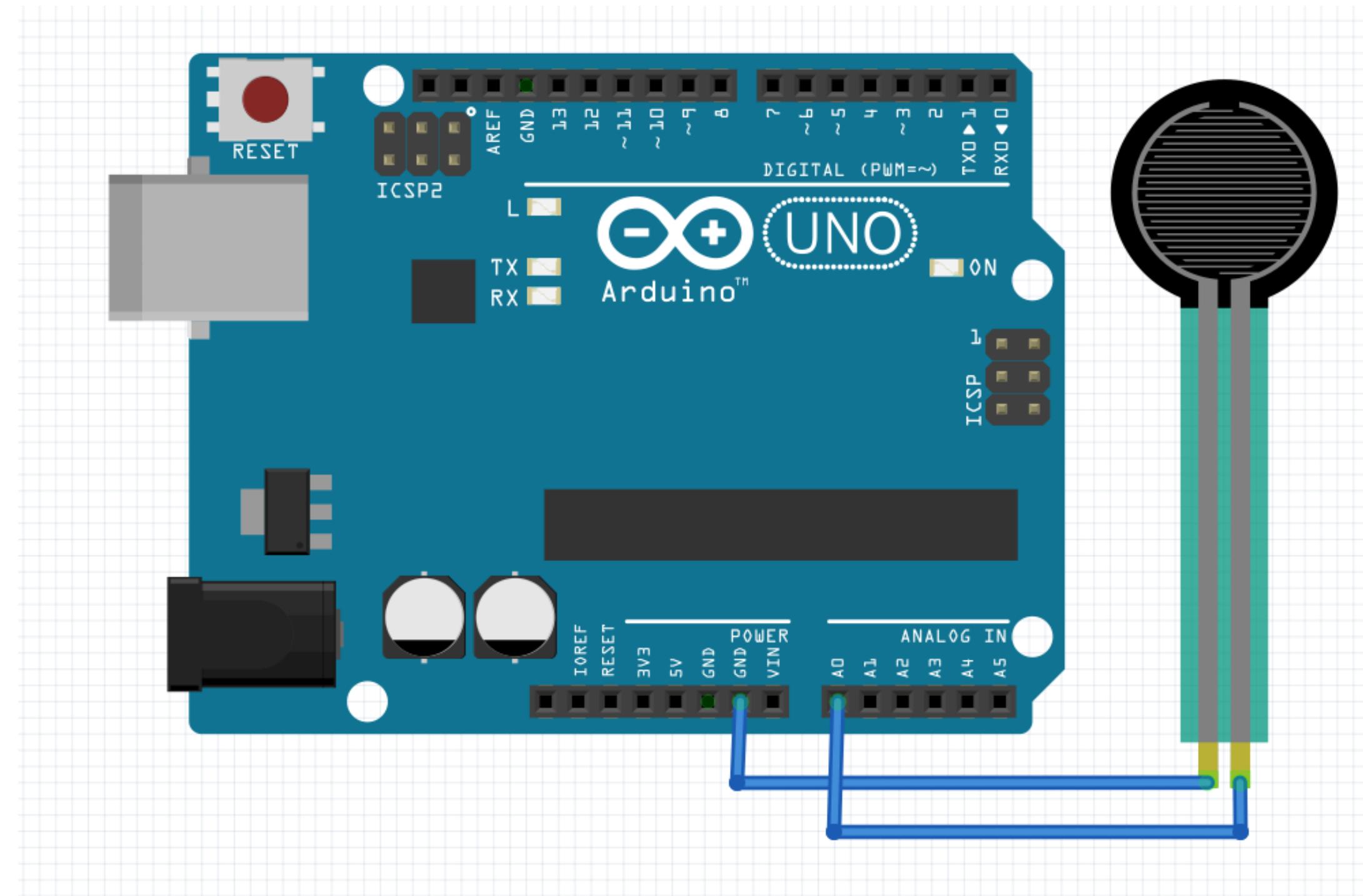
Connecting to Arduino

- /Examples/01. Basic/AnalogReadSerial



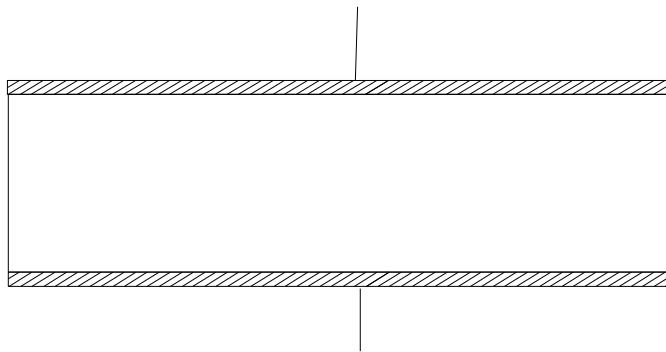
Simplifying things

Arduino has internal pull-up resistors on analog input (20 – 50 kOhm)



```
void setup() {  
    Serial.begin(115200);  
  
    pinMode(A0, INPUT);  
    digitalWrite(A0, HIGH);  
  
}  
  
void loop() {  
    int x;  
  
    x = analogRead(0);  
    Serial.println(x);  
}
```

Resistor... or capacitor?



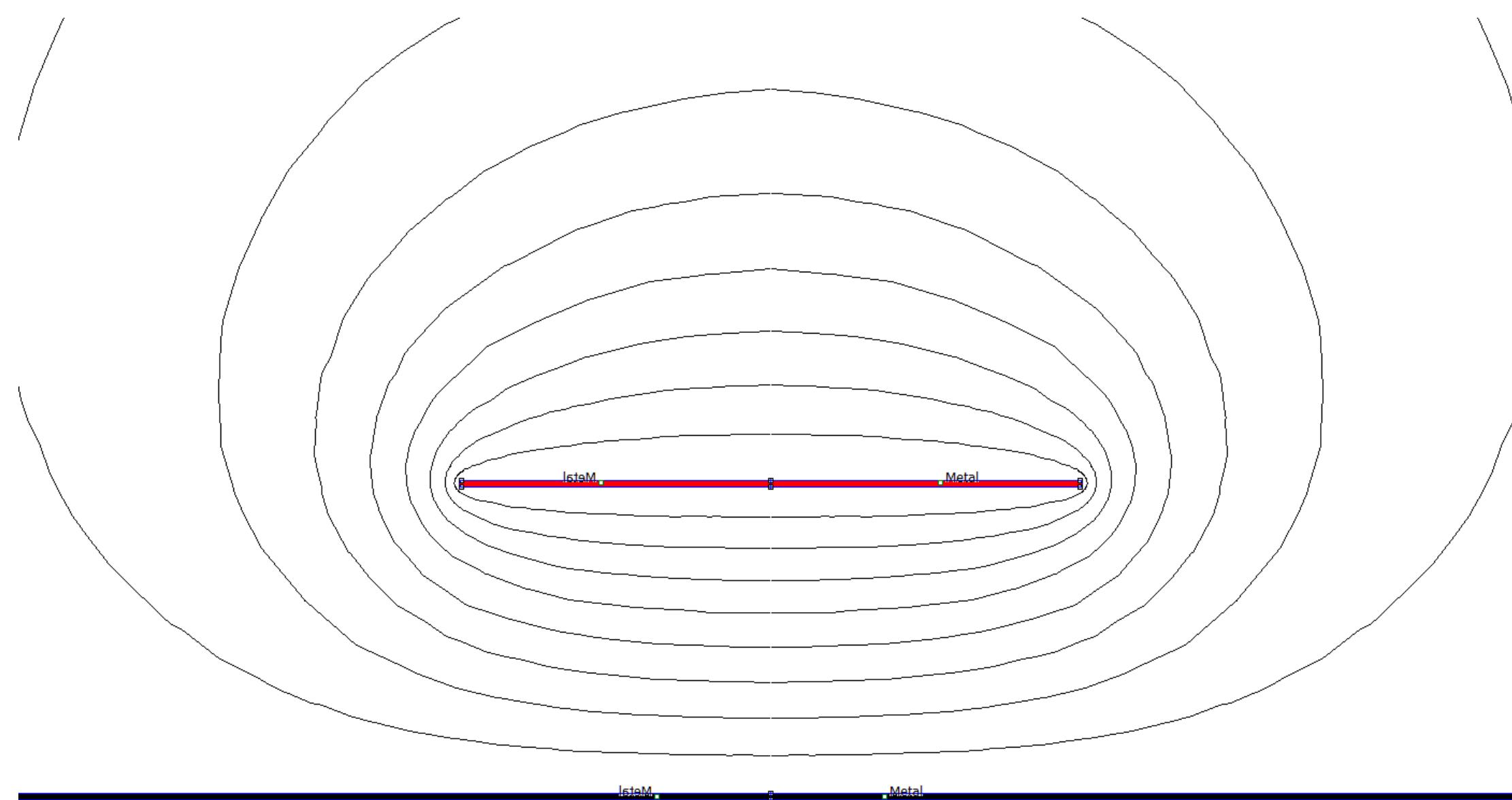
Pressure sensitive material has too low resistance to work as proper insulator.

Instead, both sides of conductive fabric + pressure sensitive material can act as one large (and thick) plate of a capacitor.

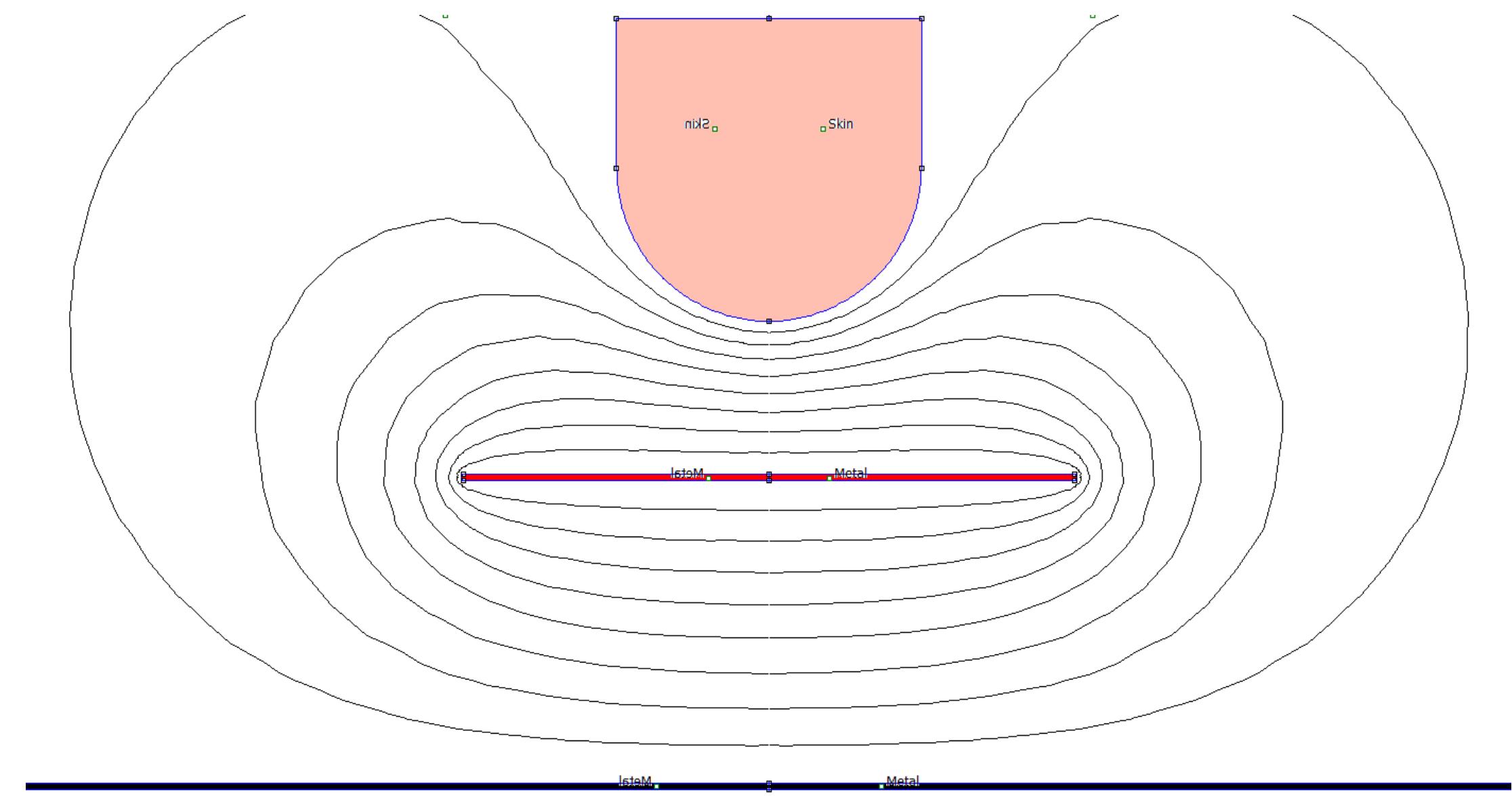
Connected to ADC, this can be used as capacitive touch sensor.

How does presence sensing work?

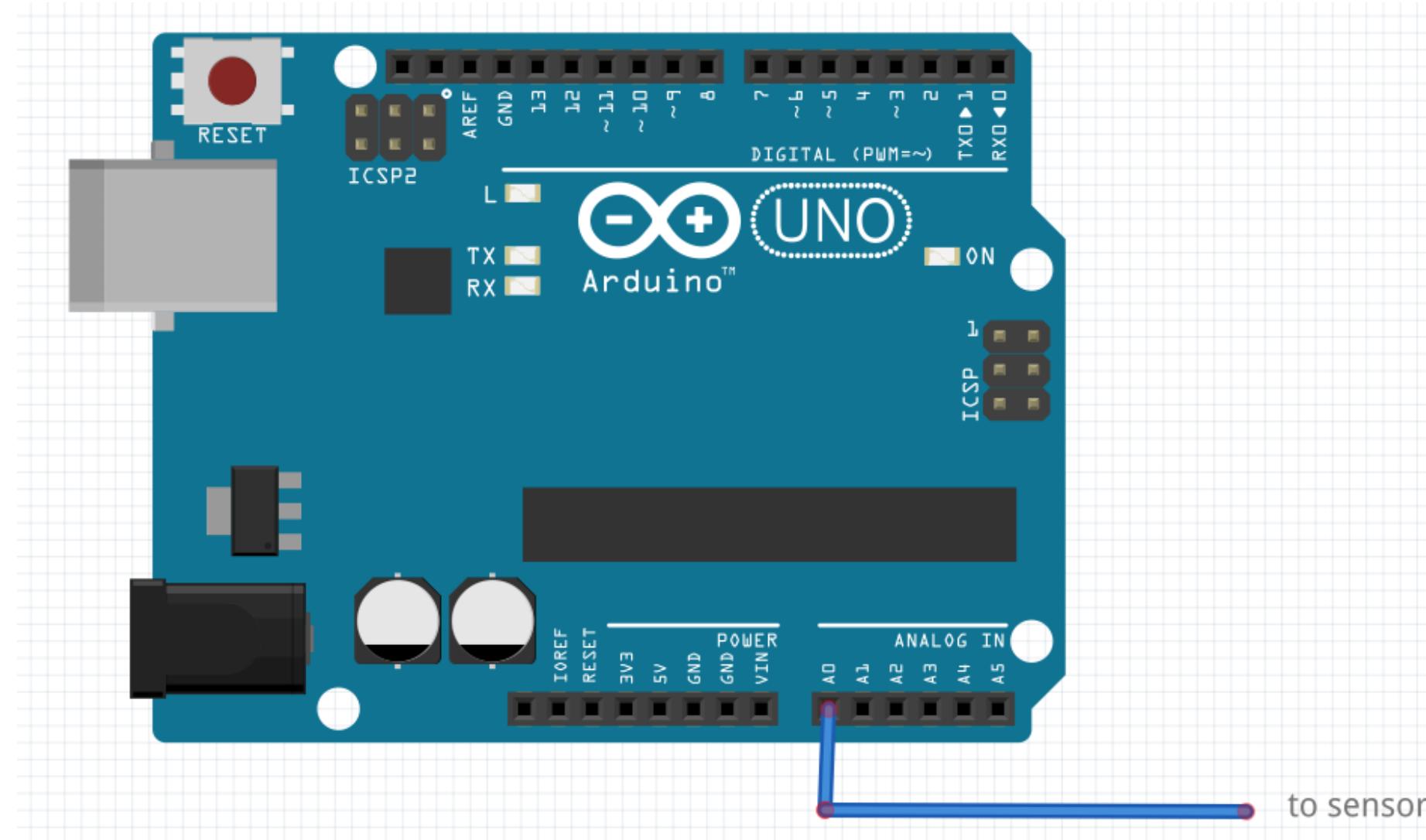
Equipotential lines



Finger presence



Wiring for capacitive sensor

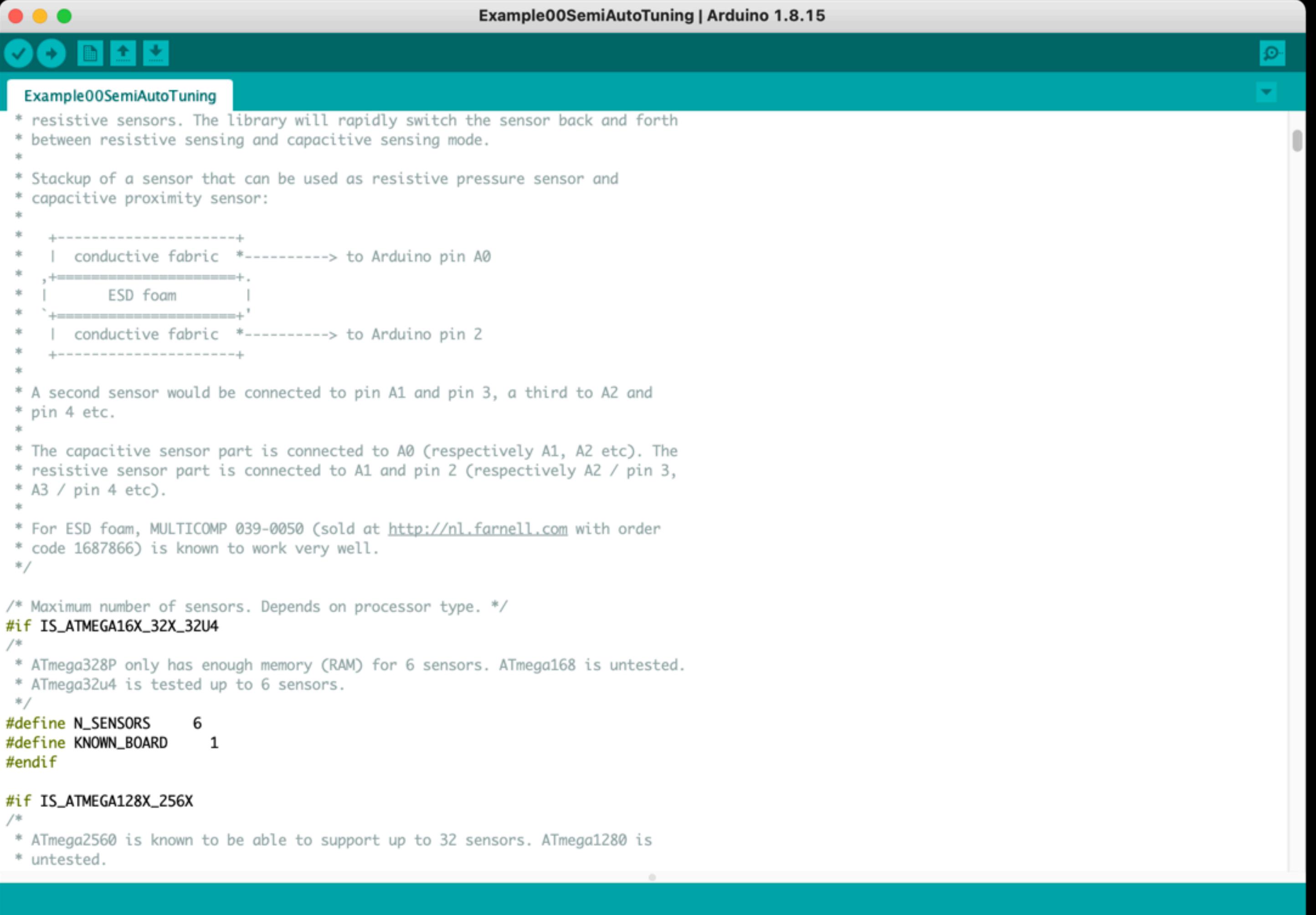


Hardware: just connect conductive plate to analog input on Arduino

Software: out of scope for this workshop, but source code is provided

TouchLib

- <https://github.com/admarschoonen/TouchLib>
- Example 00 Semi Auto Tuning



The screenshot shows the Arduino IDE interface with the title bar "Example00SemiAutoTuning | Arduino 1.8.15". The main window displays the C++ code for the "Example00SemiAutoTuning" sketch. The code includes comments explaining the connection of resistive and capacitive sensors to Arduino pins A0, 2, 1, 3, 2, 4, etc., through conductive fabric and ESD foam. It also defines the maximum number of sensors (N_SENSORS) as 6 for ATmega16X, 32X, and 32U4 boards, and up to 32 for ATmega2560. The code is color-coded for readability.

```
/*
 * resistive sensors. The library will rapidly switch the sensor back and forth
 * between resistive sensing and capacitive sensing mode.
 *
 * Stackup of a sensor that can be used as resistive pressure sensor and
 * capacitive proximity sensor:
 *
 * +-----+
 * | conductive fabric  -----> to Arduino pin A0
 * ,+=====+
 * |      ESD foam      |
 * `+=====+
 * | conductive fabric  -----> to Arduino pin 2
 * +-----+
 *
 * A second sensor would be connected to pin A1 and pin 3, a third to A2 and
 * pin 4 etc.
 *
 * The capacitive sensor part is connected to A0 (respectively A1, A2 etc). The
 * resistive sensor part is connected to A1 and pin 2 (respectively A2 / pin 3,
 * A3 / pin 4 etc).
 *
 * For ESD foam, MULTICOMP 039-0050 (sold at http://nl.farnell.com with order
 * code 1687866) is known to work very well.
 */
/* Maximum number of sensors. Depends on processor type. */
#ifndef IS_ATMEGA16X_32X_32U4
/*
 * ATmega328P only has enough memory (RAM) for 6 sensors. ATmega168 is untested.
 * ATmega32u4 is tested up to 6 sensors.
 */
#define N_SENSORS      6
#define KNOWN_BOARD    1
#endif

#if IS_ATMEGA128X_256X
/*
 * ATmega2560 is known to be able to support up to 32 sensors. ATmega1280 is
 * untested.
 */
```