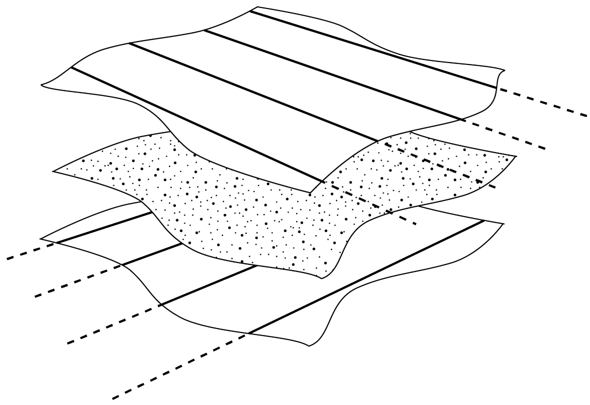
PW088-8x8/HIGHDYN
PW087-8x8/SWITCH

PRESSURE SENSITIVE MATRICIAL FABRIC

FEATURES

- FLEXIBLE MATRICIAL TEXTILE SENSOR
- TYPICAL PRESSURE RANGE: 1.8 kPa to 0.1 MPa
- SPATIAL RESOLUTION: 20 mm
- SIZE (width-height-thickness): 160-160-4 mm
- SENSITIVE AREA:50%



Matrix Sensor

DESCRIPTION

Knitted pressure sensitive fabric. Both outer sides of the fabric are made of conductive layers, while the inner layer is made of a piezo-resistive material. By pressing the fabric the piezoresistive material changes its electrical characteristics.

PRESSURE/RESISTANCE RANGES (T_{amb}= 25°C)

	HIGHDYN	SWITCH	UNIT
Maximum detectable pressure	**>0.1**	**~**	MPa
Minimum detectable pressure	**1.8 10^{-3}**	**0.2 10^{-3}**	MPa
Maximum Resistance	**>0.4**	**~**	MΩ
Minimum Resistance	**0.8 10^{-3}**	**~**	MΩ

Table 1: pressure and resistance ranges of textile pressure sensors

SENSOR STRUCTURE

The matrix sensor is made by 5 layers of fabric, the two external layers are exploited as external protection and a knitted striped fabric is glued to each external layer. The fabric is made of alternate conductive and not conductive stripes and the width of the stripes determines the resolution of the fabric. The two striped layers of fabric are at 90° with respect to each other defining a matrix of rows and columns. A piezo-resistive material is placed in between the two striped layers, and when the sensor is pressed and one row is connected to a positive voltage source, current can flow in that row and passes to the other conductive layer through the piezo-resistive material, in the area where the sensor is pressed. All 5 layers of fabric are sewn to form one unit. Flat cables connect the conductive stripes of the striped fabrics to the data acquisition unit.

FIG.B

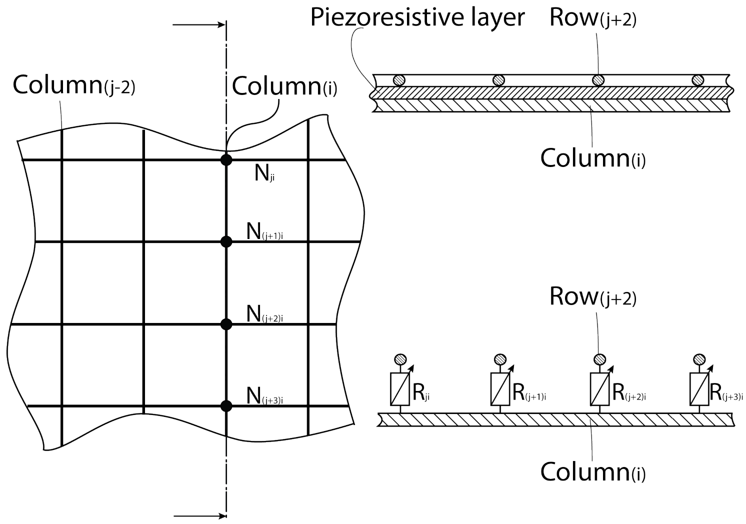


FIG.A FIG.C

Fig. 1 sensor structure

READ/ POWER SUPPLY IDEAL CIRCUIT (ARDUINO)

The sensor's reading and supply can be performed using an high input impedance data acquisition board (e.g. the Arduino platform), the other components of the circuit follows.

- one demultiplexer (DEMUX) to connect the selected row to the voltage source.
- one multiplexer (MUX) to read the selected column.
- pull down resistance (R_{pd}) of 4.7 kOhm.

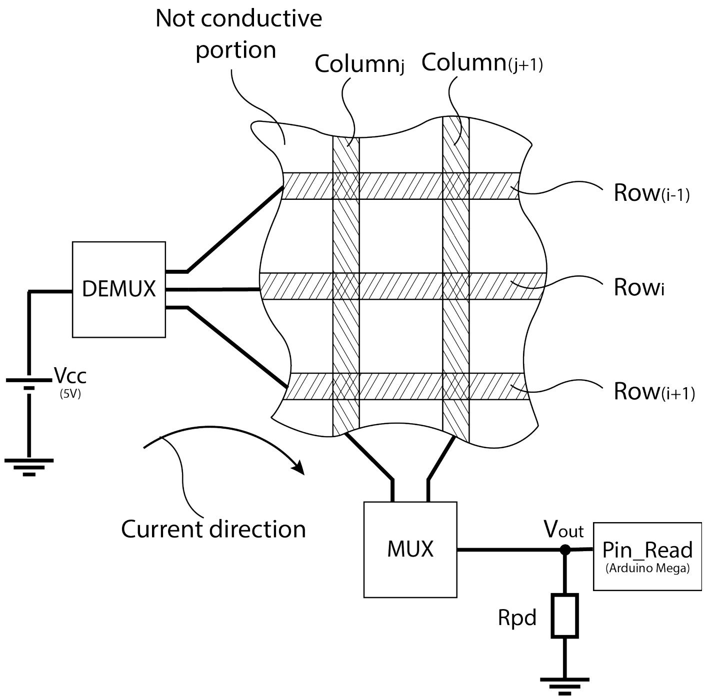


fig. 2 read/power circuit

READ/POWER SUPPLY PIPELINE EXAMPLE (ARDUINO CODE using ADG732 MUX/DEMUX by Analog Device)

Example of code for pressure sensor powering and reading.

```
const byte Ps[3]={30,31,32};//DEMUX New Switch Condition
const byte Rs[3]={40,41,42};//MUX New Switch Condition

boolean vI[3]={false,false,false};//DEMUX Old Switch Condition
boolean vII[3]={false,false,false};//MUX Old Switch Condition

const byte eP={37};//DEMUX Enable Pin
const byte eR={47};//MUX Enable Pin

unsigned int vas;
////////////////////////////
void setup()
{
        Serial.begin(115200);//speed serial communication
        pinMode(eP, OUTPUT);
        pinMode(eR, OUTPUT);

        for ( byte i = 0;i< 3; i++)
                {
                pinMode(Ps[i], OUTPUT);  //select supply line
                pinMode(Rs[i], OUTPUT);  //select read line
                }

        digitalWrite (eP, LOW);
        digitalWrite (eR, LOW);
}
////////////////////////////
```

```
void loop ()
{

        for ( byte ik = 0; ik< 8; ik++)
        {

        for ( byte i = 0;i< 3; i++)
                {
                boolean v=bitRead(ik,i);
                if (v==1 &&vI[i]==0) {digitalWrite (Ps[i], HIGH);}
                else if(v==0 &&vI[i]==1) {digitalWrite (Ps[i], LOW);}
                vI[i]=v;
                }

        for ( byte j = 0; j < 8; j++)
                {

                for ( byte i = 0;i< 3; i++)
                        {
                        boolean v=bitRead(j,i);
                        if (v==1 &&vII[i]==0) {digitalWrite (Rs[i], HIGH);}
                        else if(v==0 &&vII[i]==1) {digitalWrite (Rs[i], LOW);}
                        vII[i]=v;
                        }

                vas=(analogRead(A0));
                Serial.print(vas);
                }
        }
Serial.println();
}
```

TRANSFER FUNCTION

The transfer function relating the resistance of the textile matrix pressure sensor, Resistance =f(Voltage), is reported below. As evident from the formula, it depends on the pull down resistance.

$R(V) =(V_{cc}-V_{out})/(V_{out}/R_{pd})$.

GENERAL FORMULA

The pressure detected by the sensor can be found according to the equation below.

$P(R)= a R^b + c$.

P[Pa].

R[Ohm].

In the following table the coefficients for the different sensors are reported.

TABLE OF COEFFICIENTS(pull up resistor of 4.7kOhm)

	HIGHDYN	**SWITCH**
a	**2.3e7**	**7.154e16**
b	**-0.7582**	**-4.03**
c	**700.6**	**-1381**

Table 2. Coefficients for the different dynamics pressure sensors

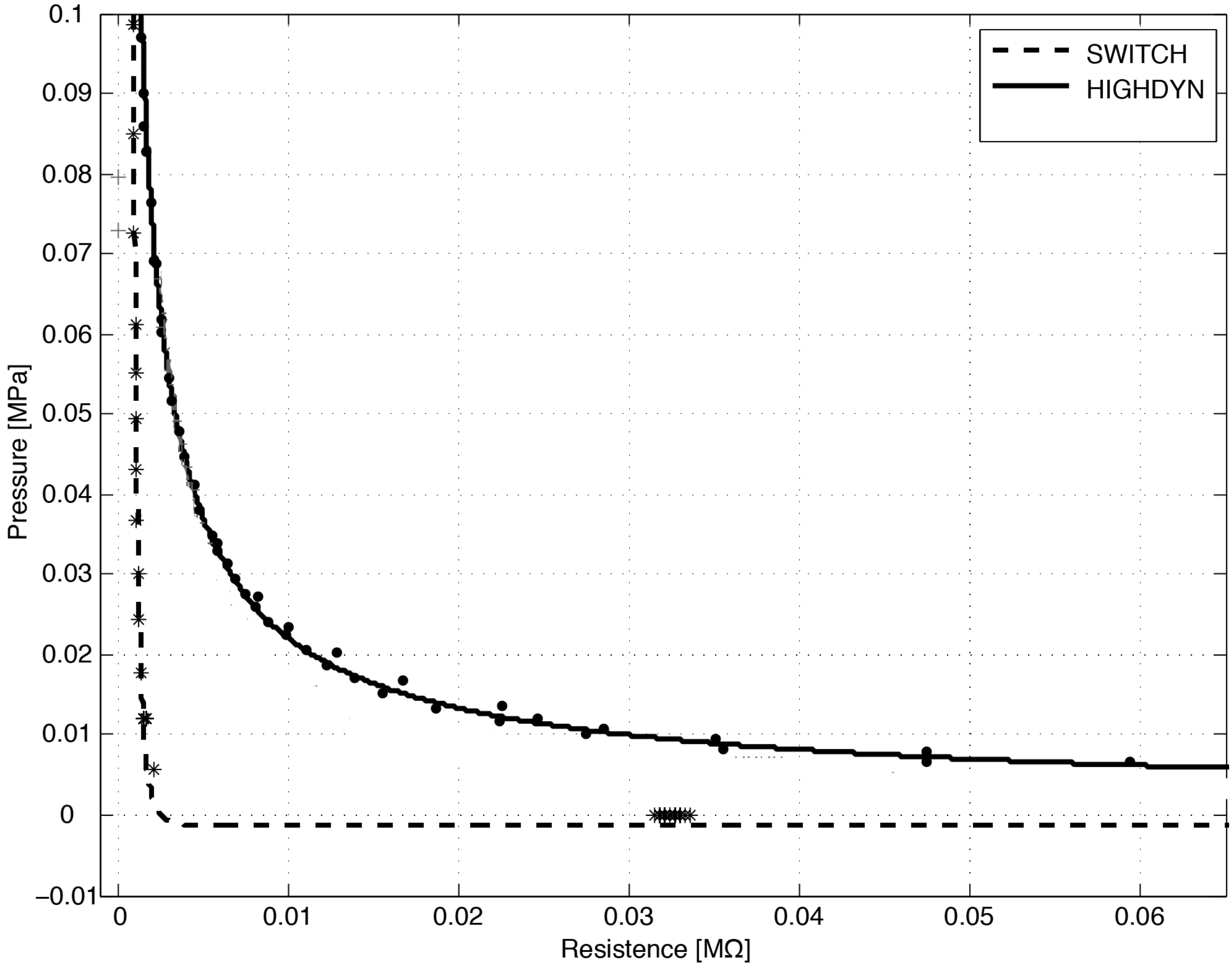


fig. 3 plot of the Pressure/resistance relationship for the different sensors

CONTACT AREA

The contact area of the pressure sensor can be calculated as follows.

- Ca=Contact area [mm^2].
- Sa=Sensitive Area = 0.02^2 [mm^2]
- R_{min}= Minimal resistance read.
- C=coefficient. Advised coefficient: 2.

FORCE CALCULATION

The equation for the evaluation of the applied force on the sensor follows.

- f_{tf}= Transfer Function.
- Sa=Sensitive Area = 0.02^2 [mm^2] R_{min}= Minimal resistance read.

- C=coefficient. Advised coefficient: 2.

CALIBRATION METHOD/ADVICES

Instron 4464 testing machine was used to apply controlled compressive load on the sensor. Tools of various diameters (20, 40, 60, 80 mm) were used to examine the sensor’s behaviour dependently by contact area.

The transfer function of the textile sensors was evaluated by applying a sequence of pressures ranging between 0 and 0.1MPa in static condition and by fitting the average behaviour of the excited sensor (fig. 3).

REFERENCE LOADS -MEASURED RESISTANCE RELATION

To determine the textile matrix sensors transfer function, Pressure=f(Resistance), the average behaviour of the excited sensor subjected to known values of compressive loads have been fitted.

VERIFY INDEPENDENCY BY LOAD POSITION

Loading different portion of the sensor verifies that each portion have the same average behaviour.

VERIFY INDEPENDENCY BY LOADED AREA

Loading the sensor with different contact areas verifies area calculation and transfer function consistency.

MULTICONTACT & CROSSTALK

The sensor can detect multi-contact, but with low loads crosstalk can happen.

MEDIAN OF PRESSURE DISTRIBUTION AND MAXIMUM PRESSURE CALCULATION (Matlab language)

- I is a matrix 8X8 that stores the pressure read by the sensor.
- CXv stores the value of x-axis coordinate of the pressure distribution median value.
- CYv stores the value of y-axis coordinate of the
- pressure distribution median value.
- Cxm stores the value of x-axis coordinate of the maximum pressure.
- Cym stores the value of y-axis coordinate of the maximum pressure.

```
%%%%%%
da=(1:1:size(I,1))*0.02;%mm
Cx=da( sum(I,1)== max(sum(I,1)) );
Cy=da( sum(I,2)== max(sum(I,2)) );

va=cumsum(sum(I,1));
CxIm=va/va(end);
CxIm=CxIm>0.5;
CxIm=cumsum(CxIm)==1;
CXv=da(CxIm);%mm

va=cumsum(sum(I,2));
CyIm=va/va(end);
CyIm=CyIm>0.5;
CyIm=cumsum(CyIm)==1;
CYv=da(CyIm);%mm

Cxm=sum(sum(I,1).*(1:size(I,1)))/sum(sum(I,1))*0.02;%mm
Cym=sum(sum(I,2).*(1:size(I,2))')/sum(sum(I,2))*0.02;%mm
```

MULTITOUCH DETECTION

A simple method to detect multiple touch events is to check the distance between the maximum pressure and the pressure distribution median.

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