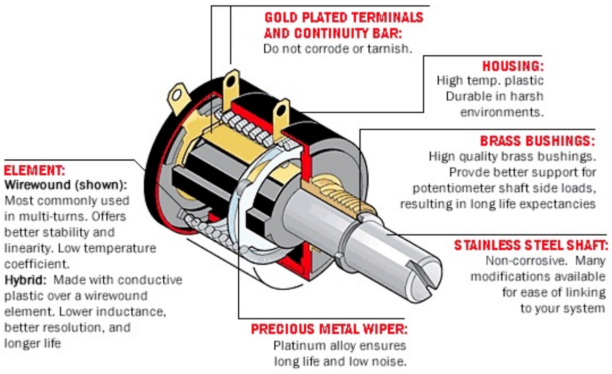
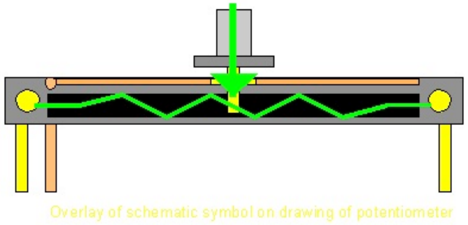
MAS836 – Sensor Technologies for Interactive Environments

Lecture 4 – Pressure Sensors Pt. 1

Position Encoders

- Displacement
  - Rotary or Linear Potentiometer
  - Linear encoder
    - Optical
    - Magneto-Acoustic
  - Shaft encoders
    - Rotary into Linear w. screw





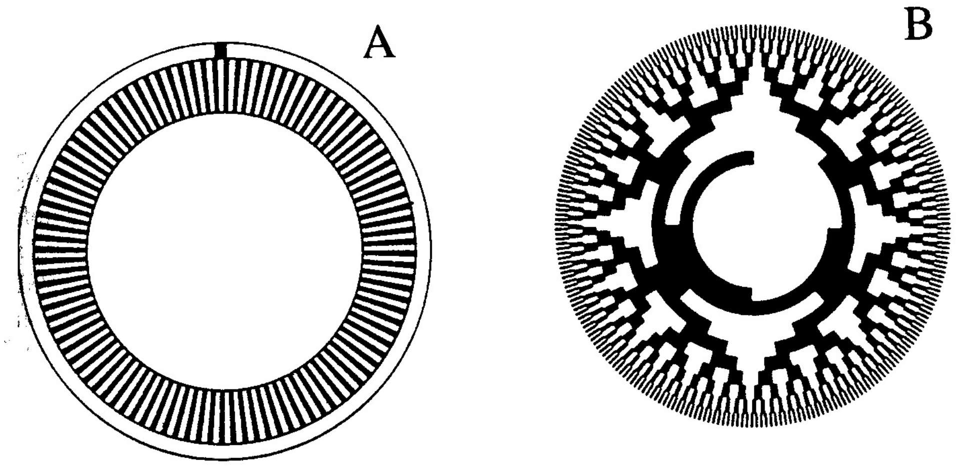
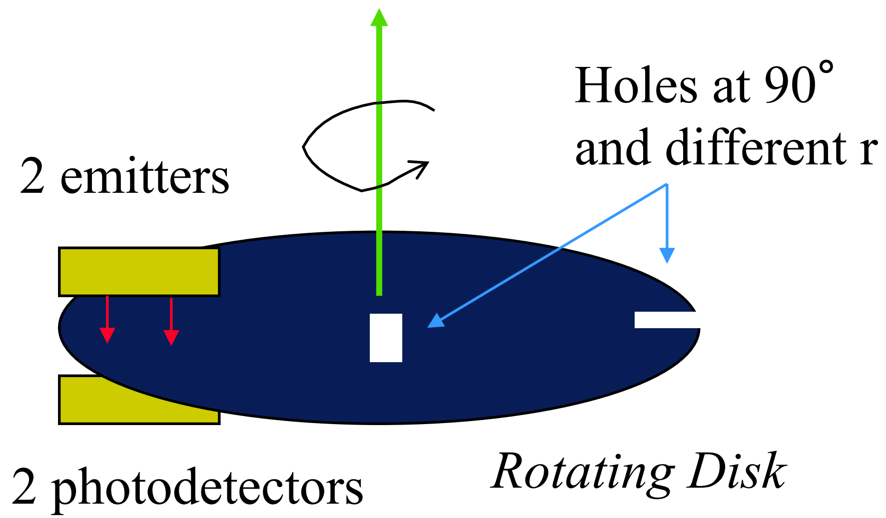


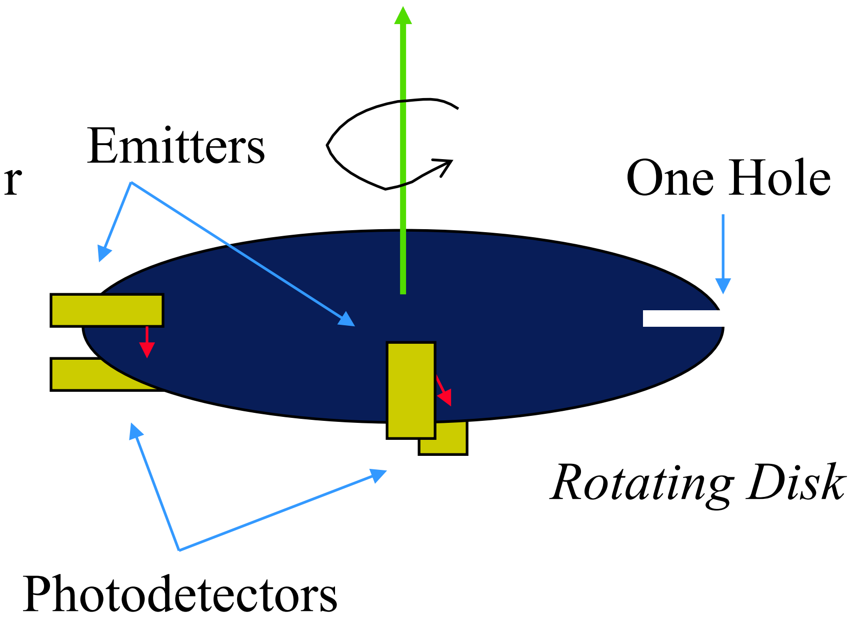
FIGURE 5.34. Incremental (A) and absolute (B) optical encoding disks.

Interface:	CANopen
Resolution/Revolution:	16 Bit = 65,536 steps
Revolutions:	up to 14 Bit = 16,384
Code	Binary
Housing Diameter:	58 mm
Shaft:	Full shaft 6 or 10 mm ø / hollow shaft 15 mm ø

Quadrature Encoders Determine Direction



2 Holes and 1 dual optical sensor



1 hole and 2 single optical sensors

One sensor measures "I" and the other measures "Q"
-> Direction determined by whether I leads Q in time or vice-versa

Can be spaced more closely, for rapid direction determination

Optical encoders

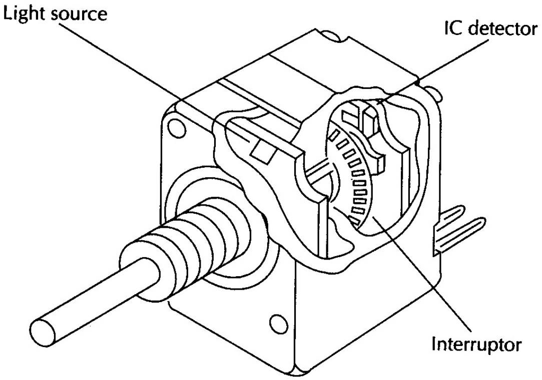


Fig. 1-52 Optical rotary encoder.

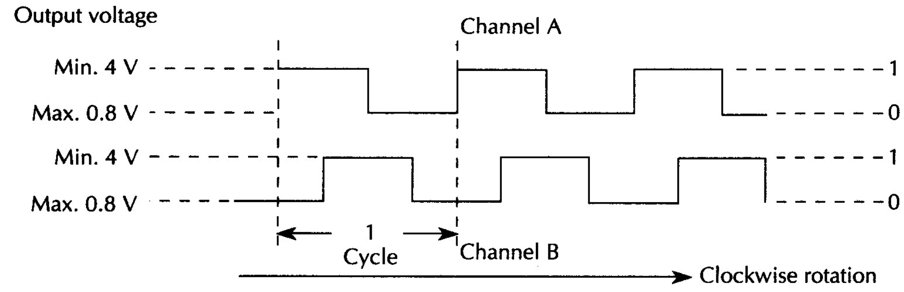


Fig. 1-54 Quadrature-output logic diagram.

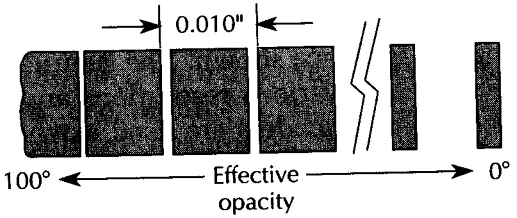


Fig. 1-56 Film strip position sensor.

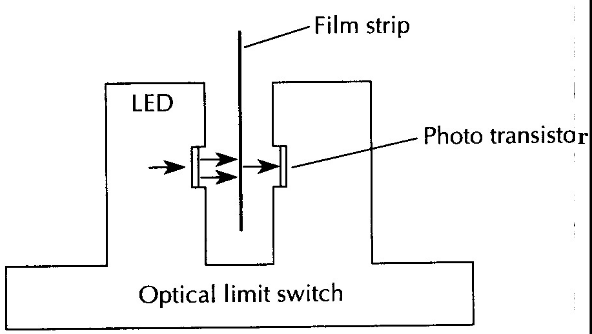


Fig. 1-57 Optical position switch.

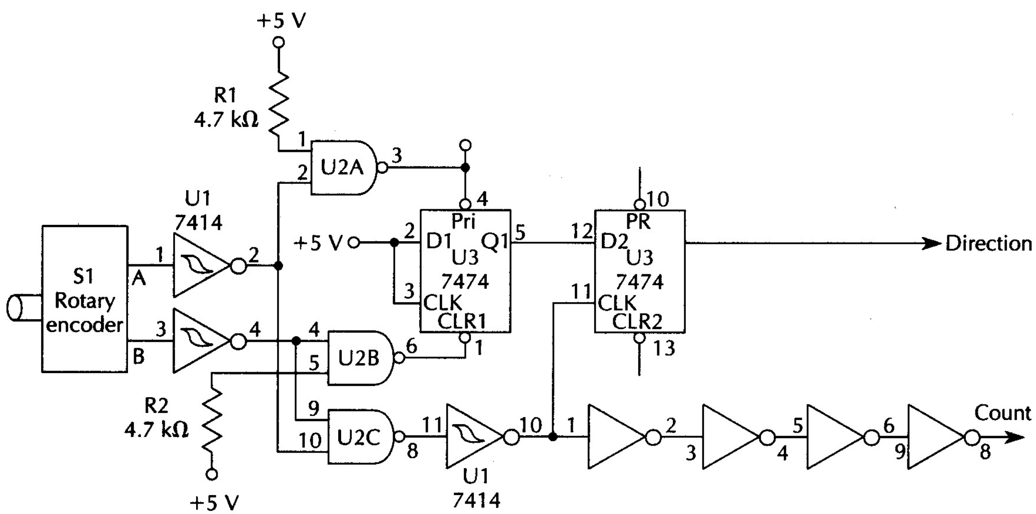


Fig. 1-55 Rotary-encoder steering-logic diagram.

Can do in a μP directly...

Better to have smoothly changing grayscale!

Linear Encoders

HEIDENHAIN Linear Encoders Click Here

Products & Specs

Optical encoders
- Track micro marks
- 100 nm accuracy!
- Film encoders are in cheap printers

Sealed Linear Encoders

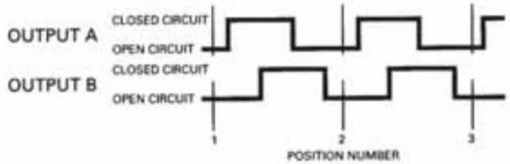
The scale and scanning unit of sealed linear encoders are protected against harsh machine shop environments by an aluminum housing with flexible sealing lips. These linear encoders are ideal for all manual and NC machine applications as well as all metal forming and wood working machines. The sealed linear scales come in several size configurations as well as lengths (over 30 meters for a single axis). Accuracy ranges from ± 10 μm to ±2 μm. Reference marks come in standard or distance-coded versions.

Exposed Linear Encoders

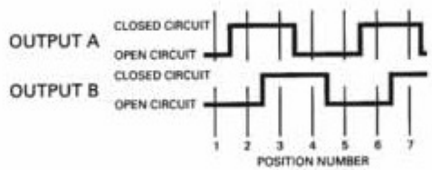
Exposed linear encoders operate with no mechanical contact between the scanning head and the scale. This eliminates any mechanical backlash or hysteresis. The measuring standard for all exposed linear encoders is a phase grating applied to a carrier of steel or glass. Applications include high accuracy test and measurement machines, manufacturing machines related to the electronics industry, and ultra precision machines such as diamond lathes, and facing lathes. Several accuracy grades (to ±0.1 μm) and size configurations (lengths to over 30 meters) as well as standard or distance-coded reference marks are available.

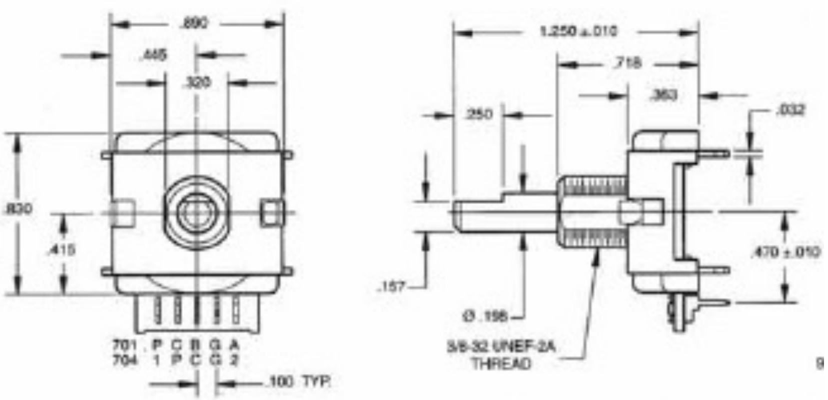
Mechanical (switch) Encoders

QUADRATURE CODE FULL CYCLE PER DETENT
(12, 16, 24 POSITION)



QUADRATURE CODE 1/4 CYCLE PER DETENT
(12,16, 24, 32, OR 36 POSITION)





For Example…

FEATURES

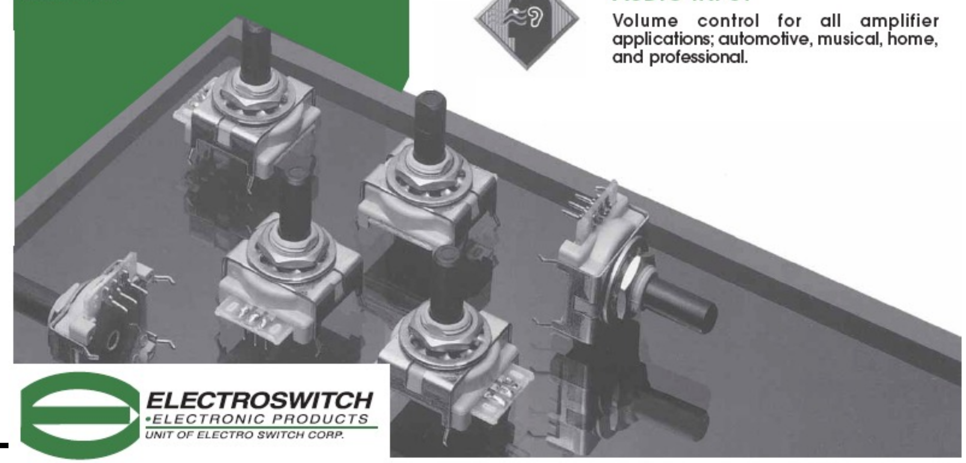
- Digital Codes Available:
  Incremental: A/B or Quadrature
  Absolute: Binary or Gray
- Up to 98 pulses per revolution (PPR)
- Analog resistive output for use as a potentiometer
- High temperature materials meet 85° requirements
- Push button feature allows dual function with single shaft input

The 700 Series is the economical solution to virtually any digital encoder or potentiometer requirement. As the latest version in our new generation of rotary encoder products, the 700 Series has been freshly tooled to include resistive analog output for potentiometer applications, as well as the standard digital code for direct interface with a microprocessor. The .890" package enhances the original design concept, delivering high performance and quality levels in the triple digit PPMs.

Electroswitch leads the market in rotational torque management for encoders. Our process includes digital maps to ensure repeatable and quantitative measurement.

Newly introduced in the 700 Series in an integrated push-button, which permits two functions in a single shaft. This feature provides system cost savings and user-friendly interface for input selection. The push-button feature is offered in the same package size as the standard 700, with a complete interface for scrolling through a menu and making a selection.

The 700 Series features a wide range of standard configurations to fulfill most needs. As with standard product, customized versions for volume applications also benefit from Electroswitch's cost-effective, automated production processes to build in quality performance.



ELECTROSWITCH
•ELECTRONIC PRODUCTS
UNIT OF ELECTRO SWITCH CORP.

700 SERIES

MECHANICAL ENCODERS

APPLICATIONS

TIMER AND TEMPERATURE SELECTION

Incremental output codes are ideal for scroll functions required for input devices. Resistive output for temperature input selection.

HVAC TEMPERATURE AND FAN CONTROL

Digital or analog output for temperature with direct drive to display and fan control for automotive use.

ELECTRONIC RANGE CONTROL

Control of bake time, temperature and duration in residential and commercial applications.

PANEL INPUT DEVICE

Used to scroll through menu via shaft rotation; for selecting menu item via push-button.

AUDIO INPUT

Volume control for all amplifier applications; automotive, musical, home, and professional.

Magnetic Encoders

ELECTROSWITCH
•ELECTRONIC PRODUCTS
UNIT OF ELECTRO SWITCH CORP.

500 SERIES MAGNETIC ENCODERS

NEW

The Electroswitch 500 Series Magnetic Encoders are built upon a contact free integrated circuit design. This encoder integrates Hall Effect sensing and digital signal processing to provide high-resolution angular measurement solutions.

An important advantage of the 500 Series is the dramatic reduction in package size to ½ inch, while still incorporating the performance and output options required to support the widest range of industrial and motion sensing applications.

The 500 Series design leverages its reduced part count and simplified construction to provide extremely robust, high shock and vibration resistant performance, excelling in harsh and dirty environments.

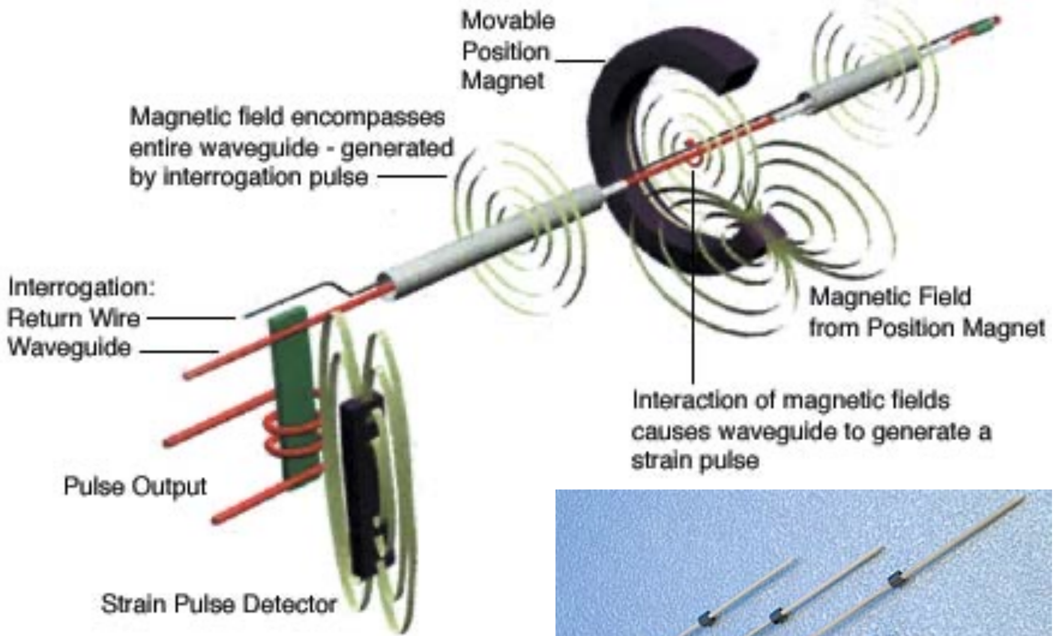
FEATURES

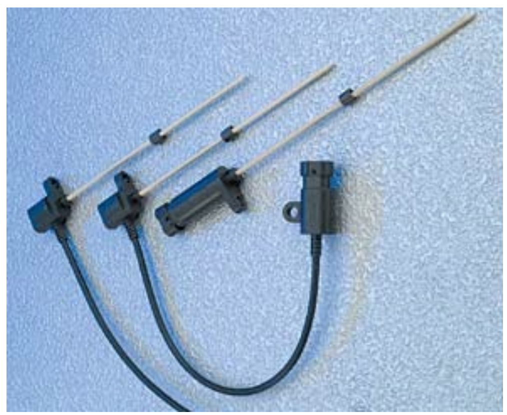
- Compact, Robust, 1/2" package
- High Resolution Encoding up to 1024 PPR
- Widest Temperature Range
- Absolute and Incremental Outputs
- Zero Reference Positioning
- Tachometer with Direction Sensing
- Quadrature Code Output
- RoHS Compliant
- Contact Free Magnetic Design
- 3.3 or 5.0 VDC Options

BENEFITS

- Compact Size
- Multiple Output Codes Allowing Simpler Integration With a Wider Variety of Receiving Devices
- Best Encoder Reliability
  - Longest Life
  - Excellent Performance in Harsh Environments
- Low Power Consumption

Magneto-Acoustic Linear Encoders





- 1 mil per sample, 9 kHz updates
- Must measure T too!
- MTS Sensors

How Magnetostriction Works

Magnetostriction is a property of some ferromagnetic materials in which the material expands or contracts when placed in a magnetic field (see Figure 1). The sensing element of a magnetostrictive position sensor is the waveguide, a long, thin ferromagnetic wire or tube. Another property of these materials is the Wiedemann effect: when a current is passed through the waveguide in the presence of an axial magnetic field, a torsional force is exerted on the waveguide. The sequence of events in a position measurement are:

1. A current pulse, called the interrogation pulse, is applied to the waveguide (the circuit is completed with a copper return wire), and a timer is started.
2. A torsional force is generated at the location of the position magnet due to the Wiedemann effect. This produces a sonic pulse that travels down the waveguide, traveling at the speed of sound in the waveguide material.
3. When the sonic pulse arrives at the sensor element head, it is detected and the timer is stopped.
4. The elapsed time represents the distance between the position magnet and the sensor element head. Long-term stability and temperature sensitivity are controlled by the speed of sound in the waveguide material.
5. The time period measurement is used to produce the desired output, such as analog voltage, 4–20 mA, pulse width modulation, CAN bus, SSI, etc.

Accurate, noncontact position sensing is thus achieved with absolutely no wear to any of the sensing elements. Since a return pulse will be generated for each magnet located along the sensor, sensors can be designed with multiple marker magnets.

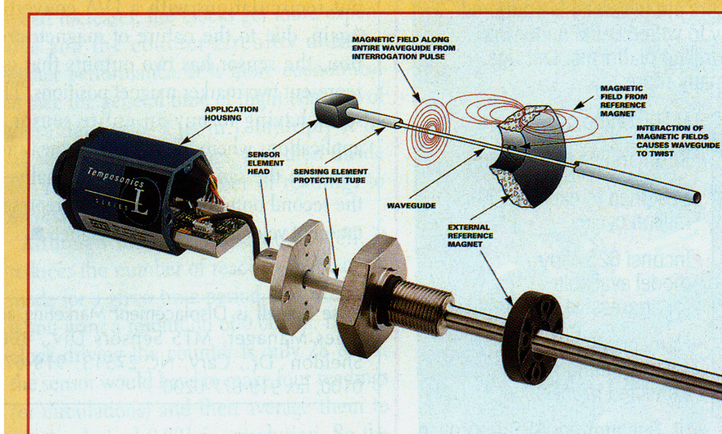
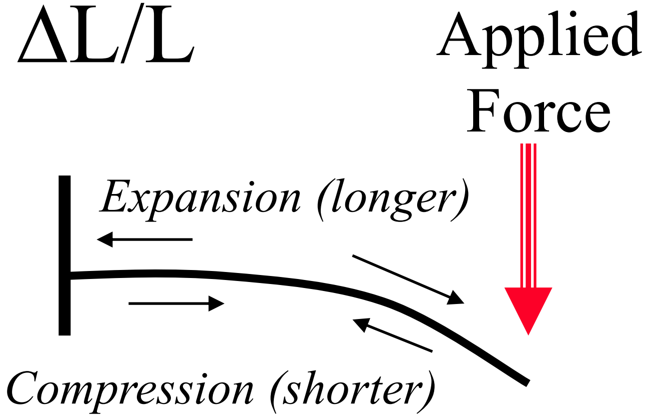


Figure 1. *In a magnetostrictive position sensor, a pulse is induced in a waveguide by the momentary interaction of two magnetic fields, one from a reference magnet and the other from a current pulse launched along the waveguide. The interaction produces a strain pulse that travels along the waveguide and is detected at the sensor head. The position of the magnet is determined by measuring the elapsed time between the launching of the electronic pulse and the arrival of the strain pulse.*

Pressure

- Displacement into pressure
  - E.g., F = -kx, and P = F/A (force per area)
- Strain into Force
  - Strain is defined by s = ΔL/L
- Piezoresistivity



Note: Mark Feldmeier made nice pages about FSRs, etc.:
http://www.openmusiclabs.com/learning/sensors/

Membrane Switch

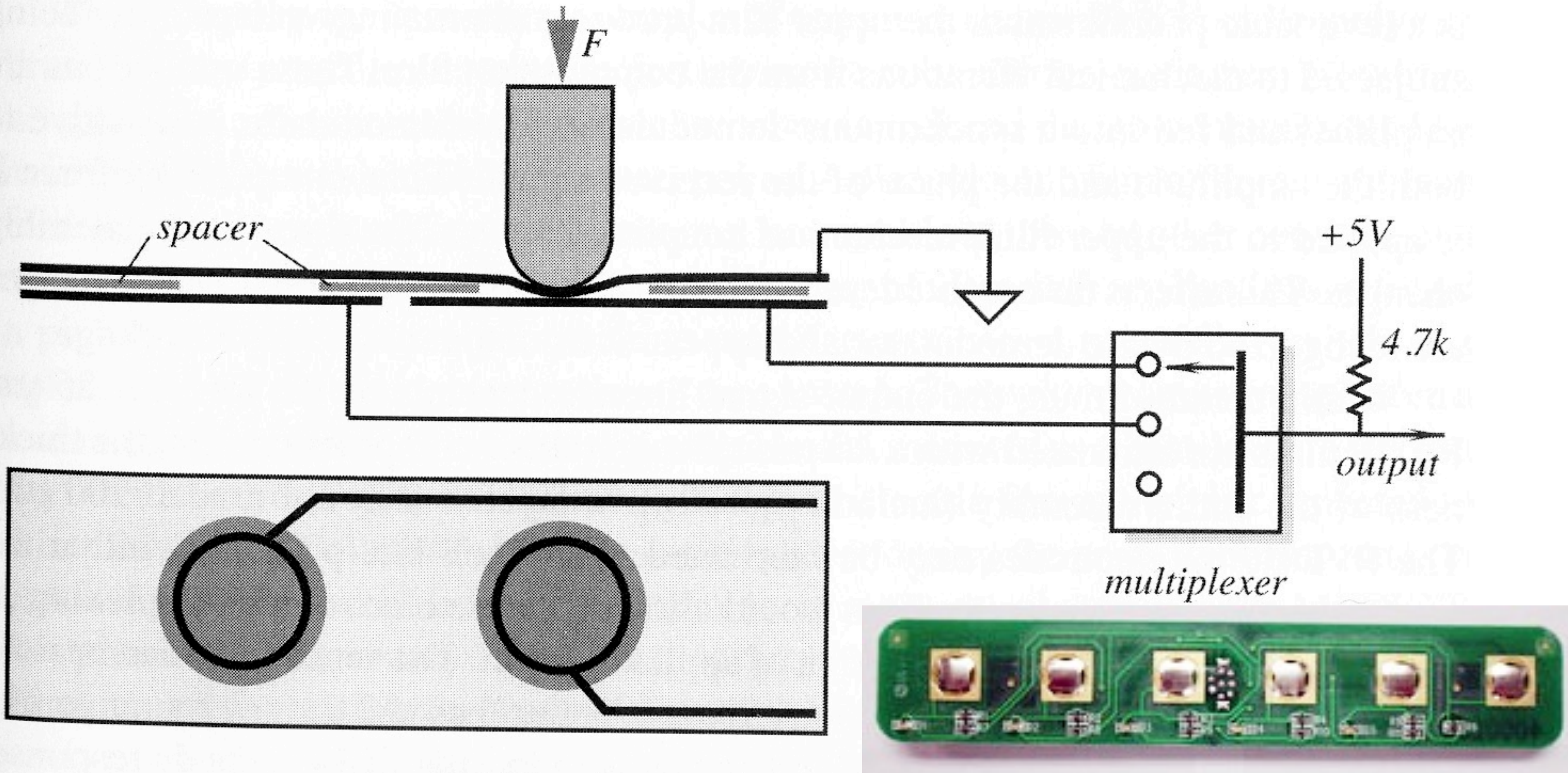
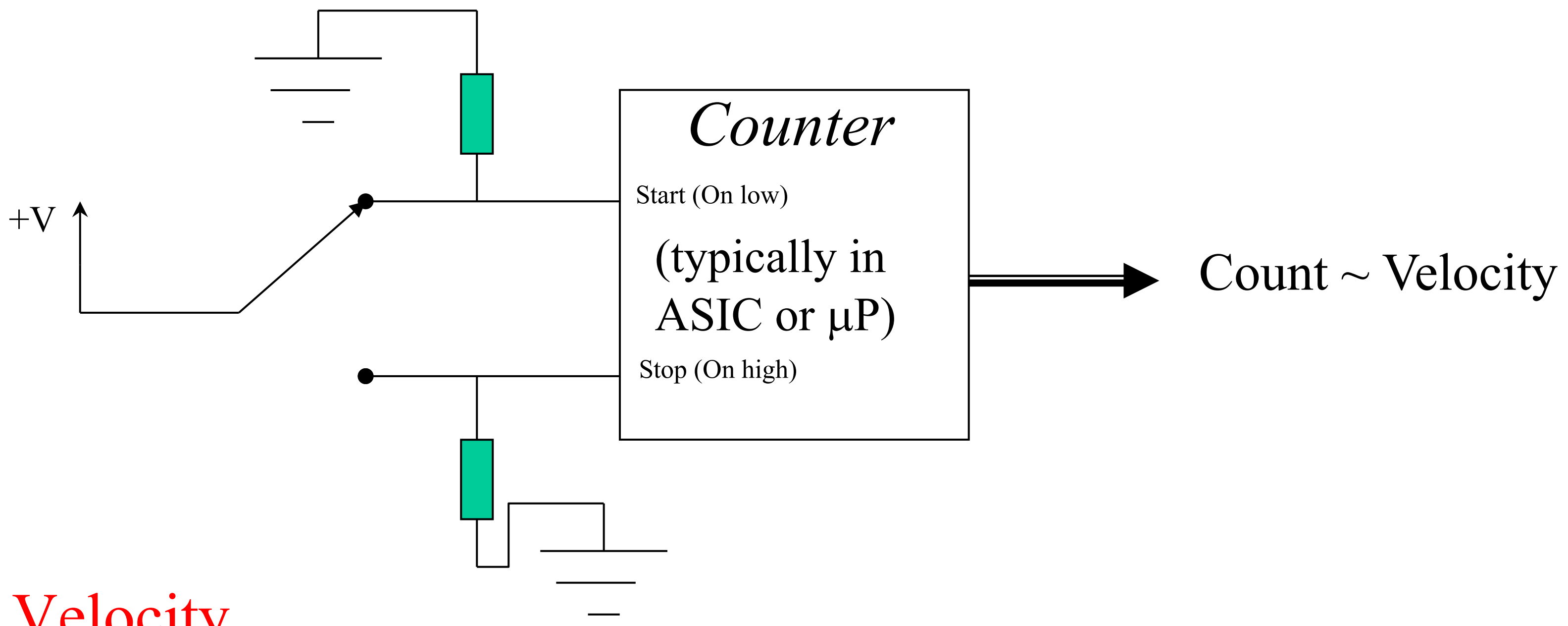


Fig. 9.3. Membrane switch as a tactile sensor.

- Commercial – can be printed and snap-assembled
  - Made by ALPS among others (switch floor too)
  - Typically polled in row-column fashion (e.g., drive columns, read rows)

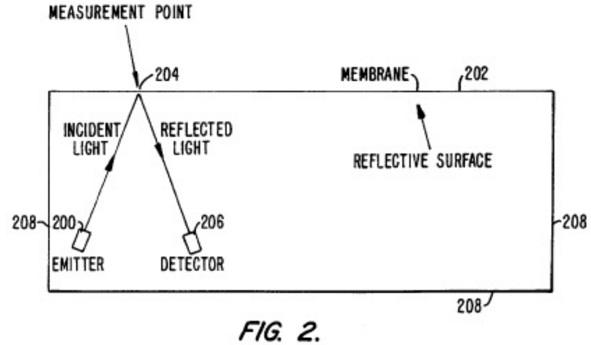
How a MIDI Keyboard Works

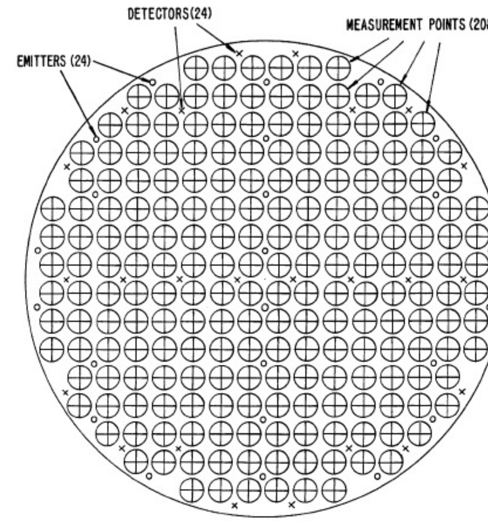


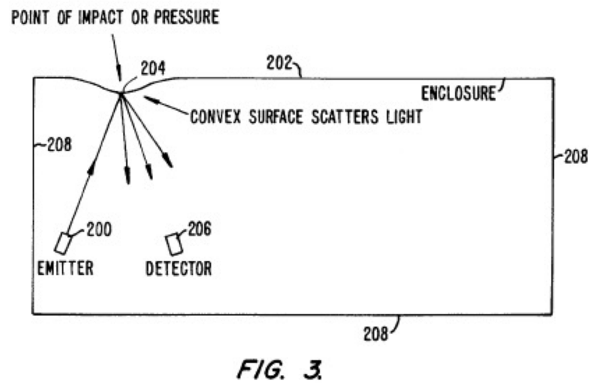
- Velocity
  - Measure time difference between key transitions
- Aftertouch
  - FSR underneath keys
    - FSRs were developed for this purpose (Interlink)
  - Poly aftertouch has FSR under each key
  - Mono aftertouch has FSR under key bank

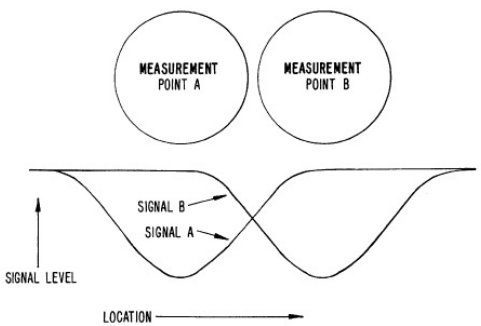
The Buchla Thunder

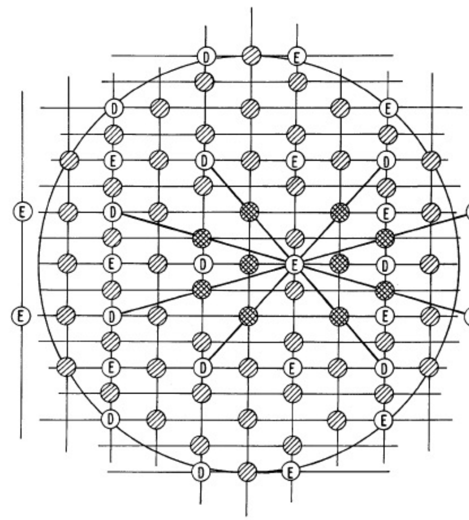
Thunder 1 - with capacitance











- Thunder 2 Tracks multipoint finger position optically using reflective back of mylar drumhead.
- Thunder 1 used capacitance

US Patent 5,913,260 - June 15, 1999 Donald F. Buchla
System and method for detecting deformation of a membrane

Optical Pressure Sensors

Figure 3: Camera view of membrane: (a) undeformed (b) in contact with an object.

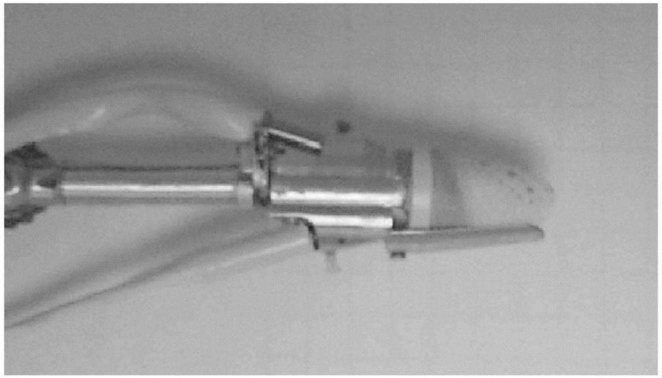
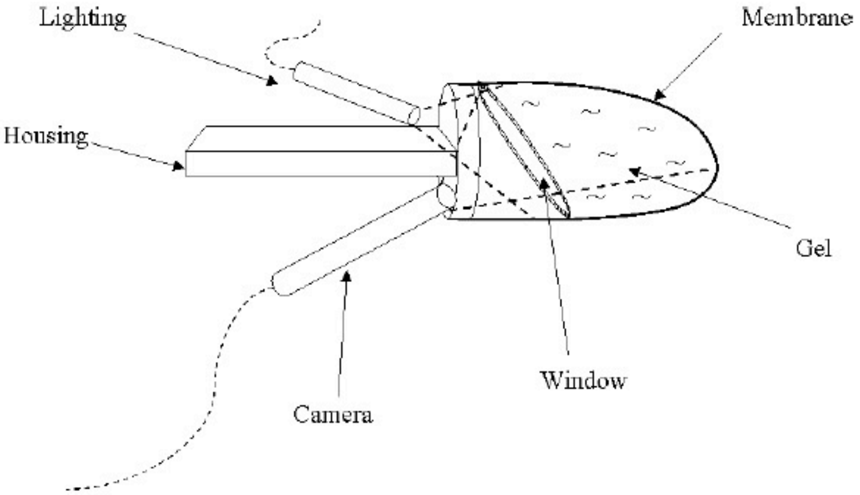
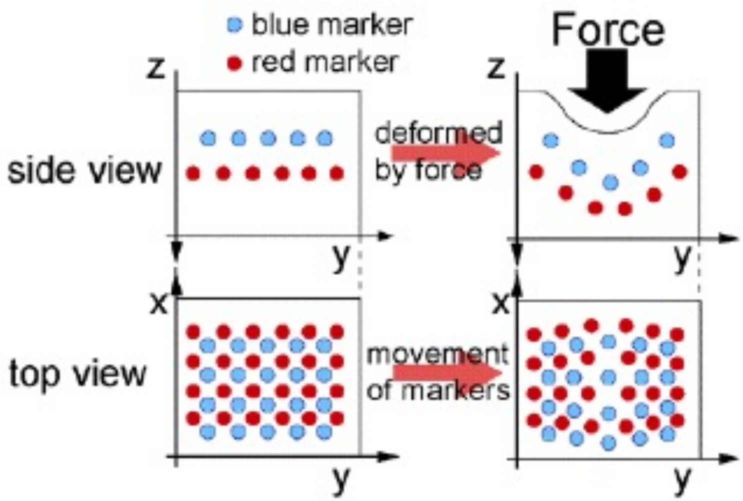


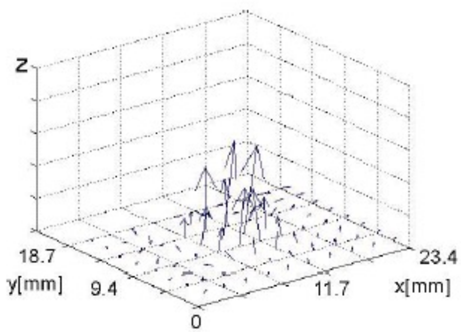
Figure 1: The tactile sensor.

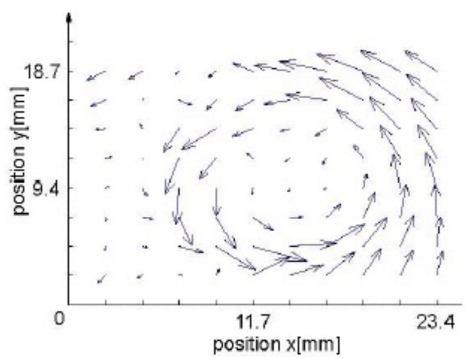
- Pressure Profile of deformable dot-matrix fingertip (Hristu, Ferrier & Brockett)



GelForce (U. Tokyo – Kamiyama et al)







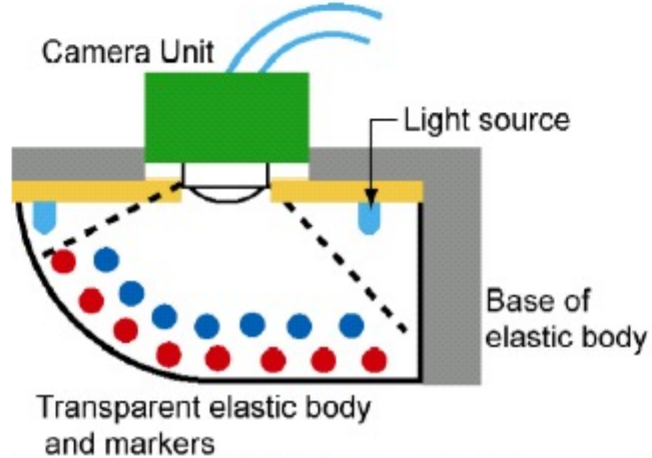
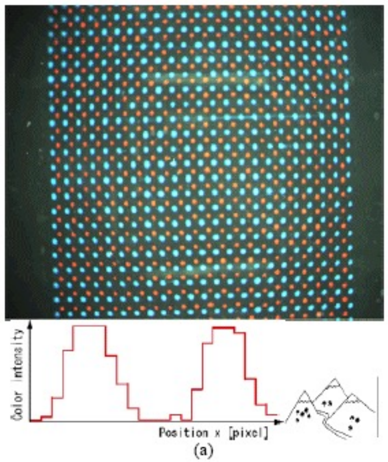


Figure 10: Endowing an robotic finger with the sense of touch

http://www.youtube.com/user/tachilab#p/c/ED698D863C3EB87E/17/VWtUSoBqdVo

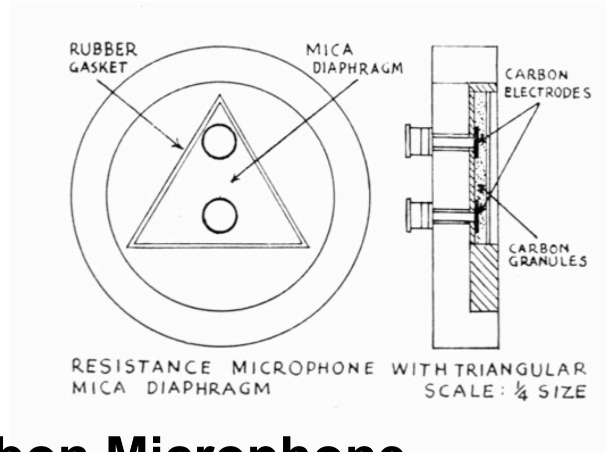


Dual layers resolve both normal and shear forces

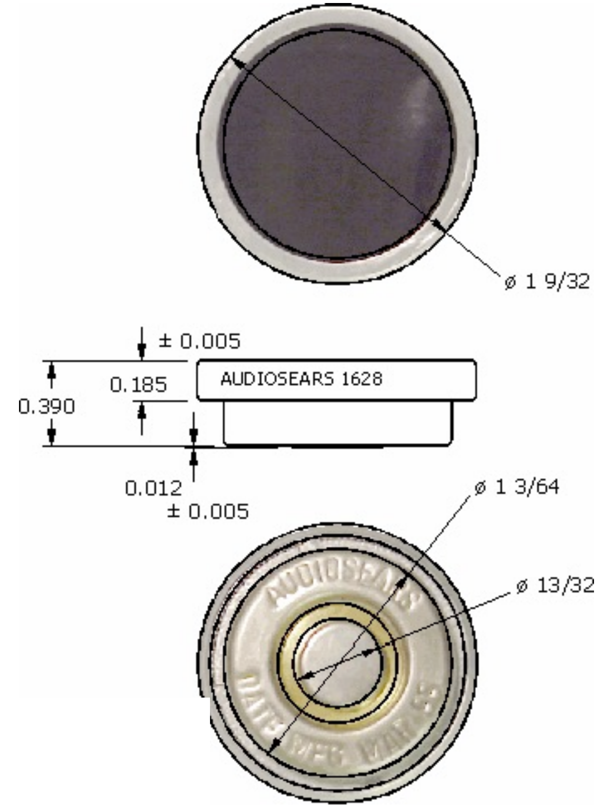
– *Derive pressure vector*

The Carbon Microphone – Sonic FSR

1878



1929

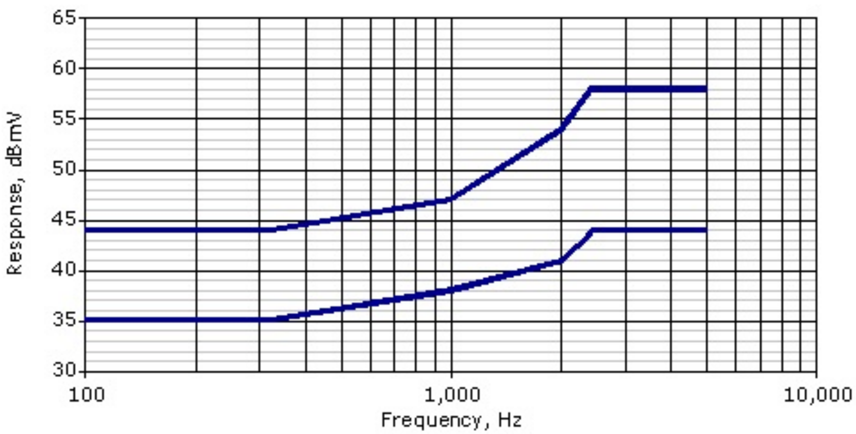


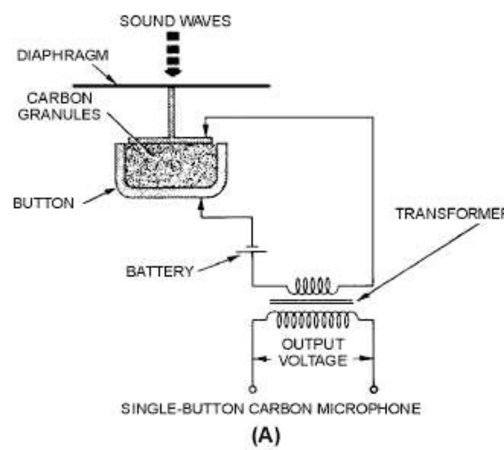
1628 N-1 Type Carbon Microphone

Microphone Characteristics

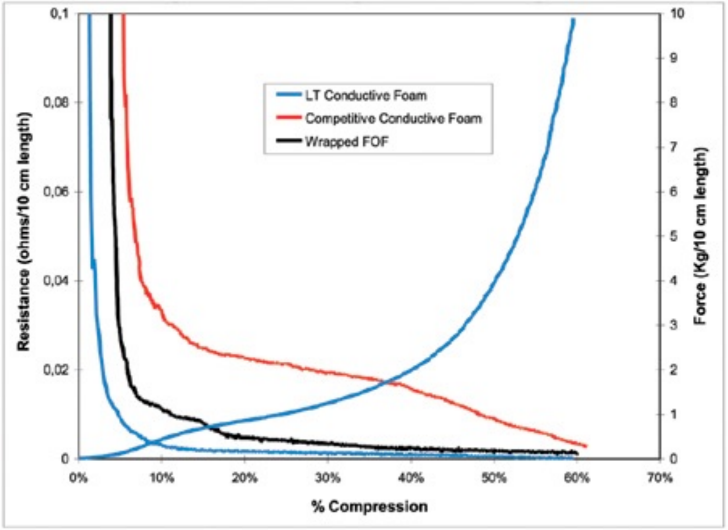
A. Minimum Sensitivity @ 1 kHz with 85 mA(DC) Applied Current: 38 dBmV

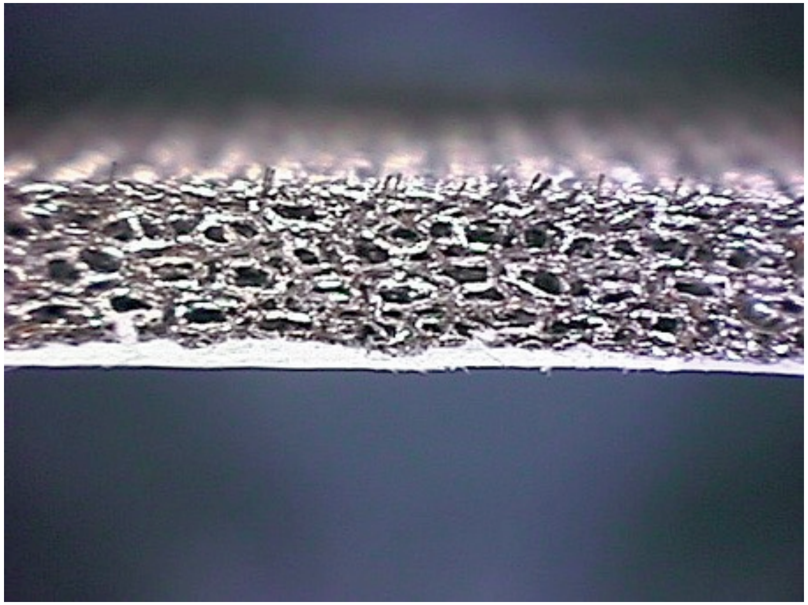
B. Impedance Range: 15-60 ohms

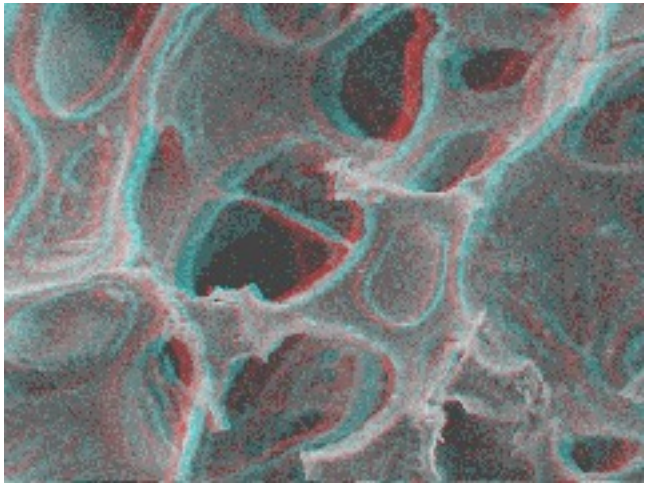




Conductive Foam





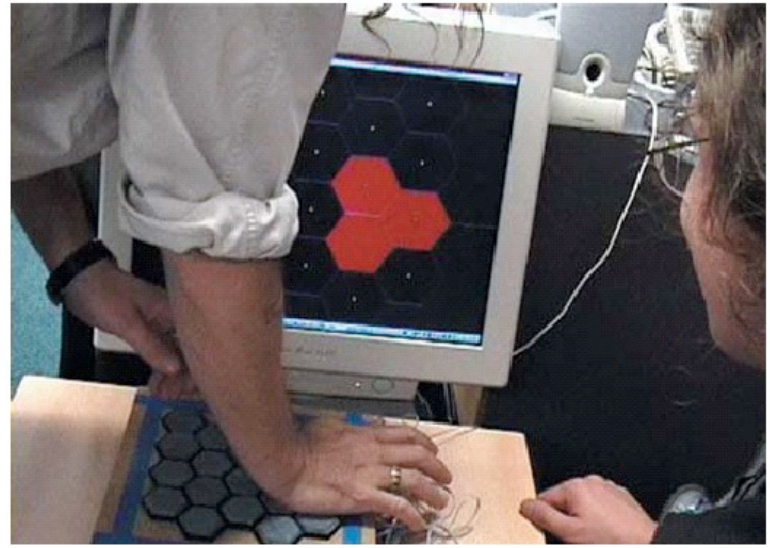


Metalized

Standard (3D!), e.g., ‘Velostat’

Resistive (conductive) Elastomers

Figure 2. Freshly made polymer sensor applied to circuit board

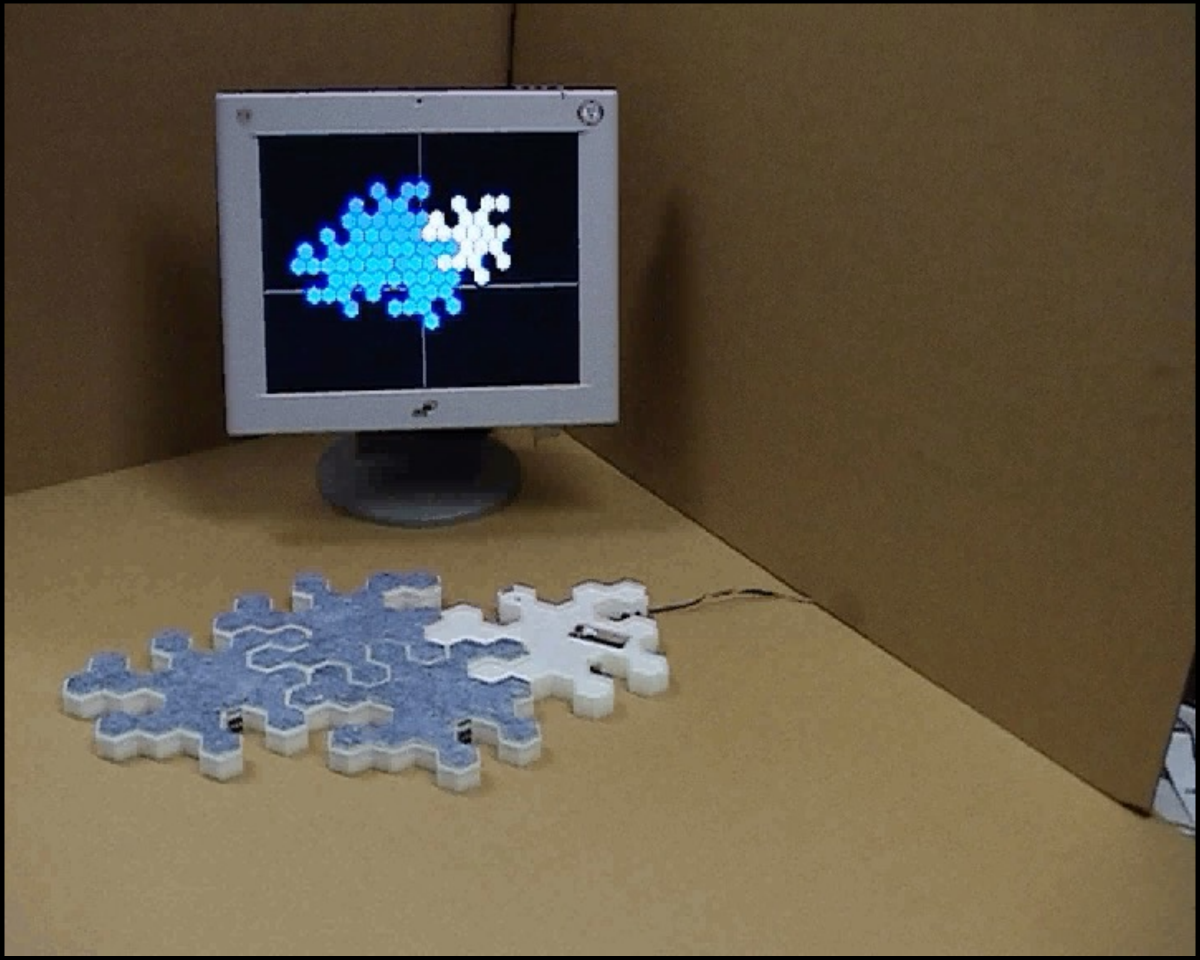


Early Z-Tiles from the University of Limerick

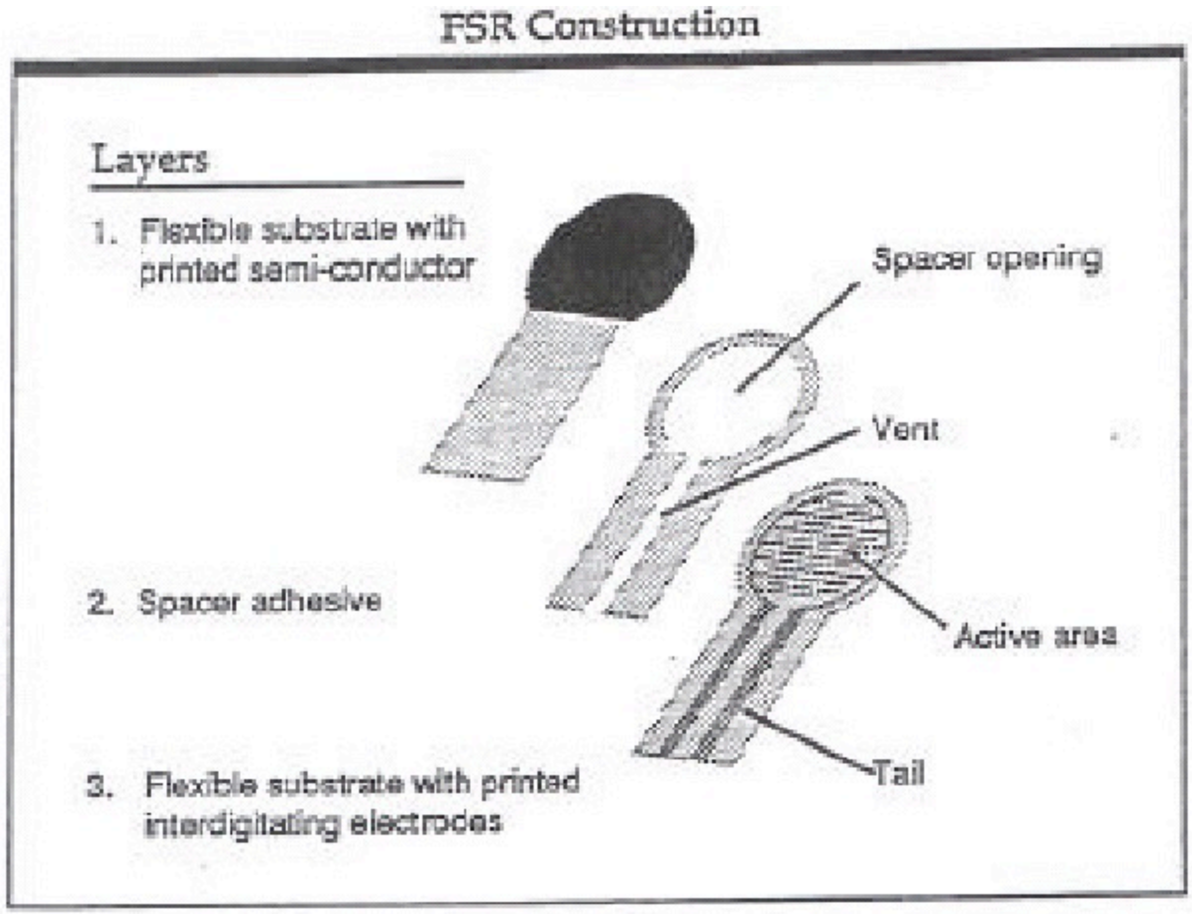
McElligott, L., et al, 'ForSe FIElds' - Force Sensors for Interactive Environments," in UbiComp 2002

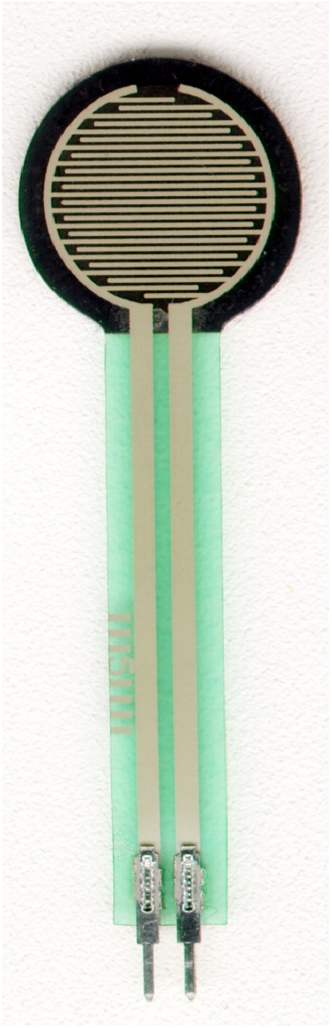
- Carbon or silver-loaded silicone rubber
- Dynamic range limits, hysteresis, longevity…
- Commercial conductive rubber from:
  - "Zoflex" from Xilor, inc. (rfmicrolink.com)

See: Koehly et al, "Paper FSRs and Latex/Fabric Traction Sensors: Methods for the Development of Home-Made Touch Sensors," Proc. Of NIME 06



Force Sensitive Resistors





- Composite structure
  - Top, ink, electrodes
    - Flat, but can be fragile to shear force (delamination) and sensitive to bend

Conductive Polymers and FSR's

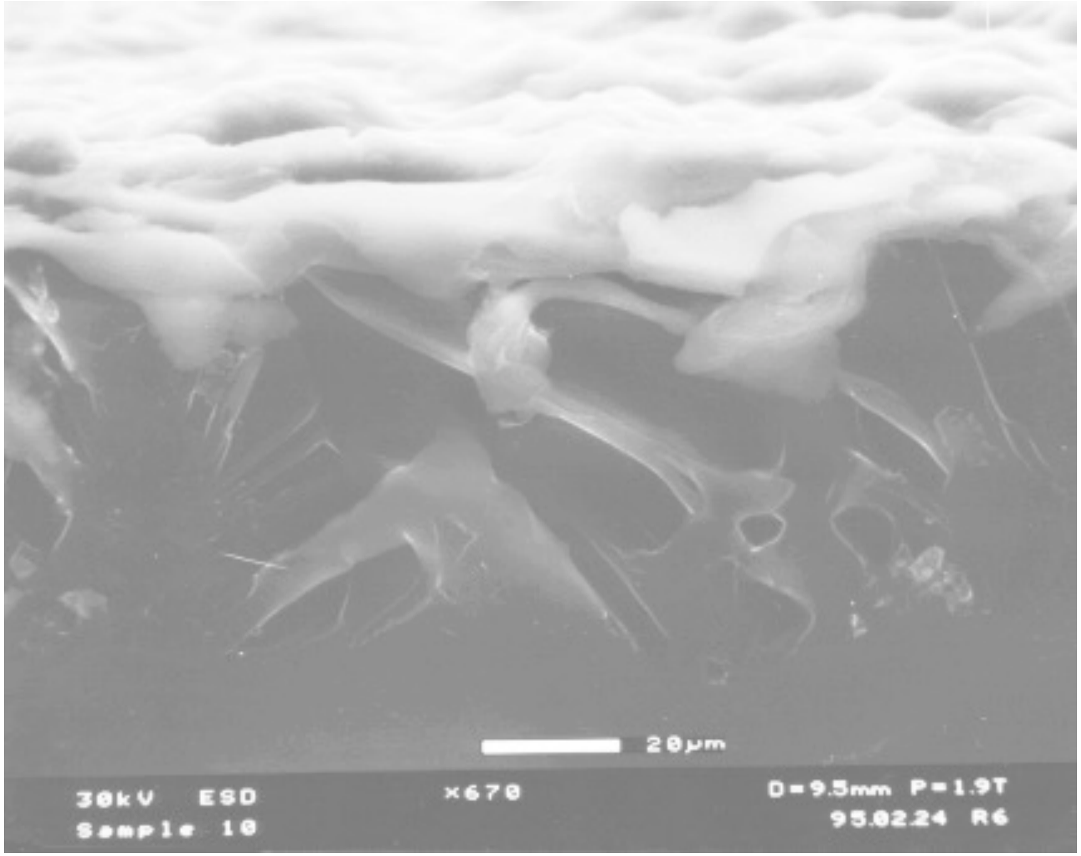


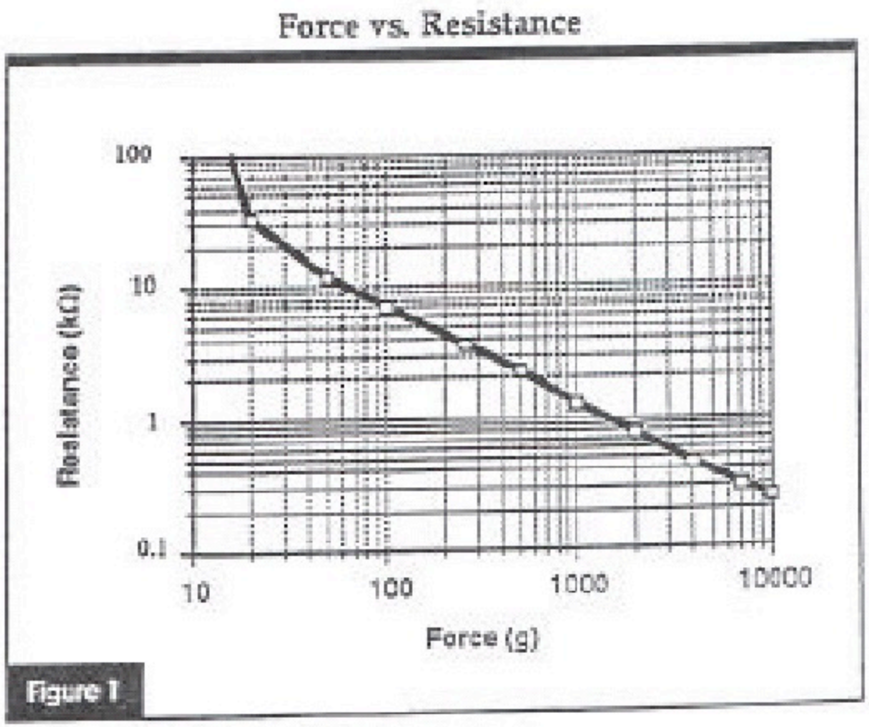
Photo by
Rich Fletcher, MIT ML

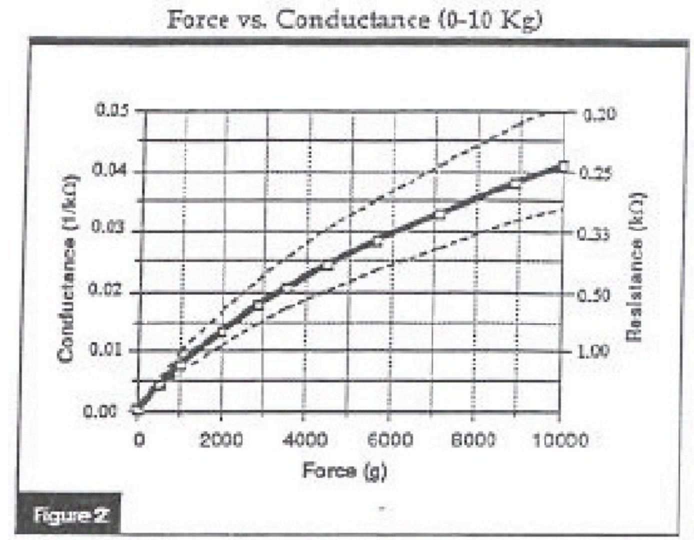
- Microphotograph, showing conductive ink and metalization from Interlink FSR

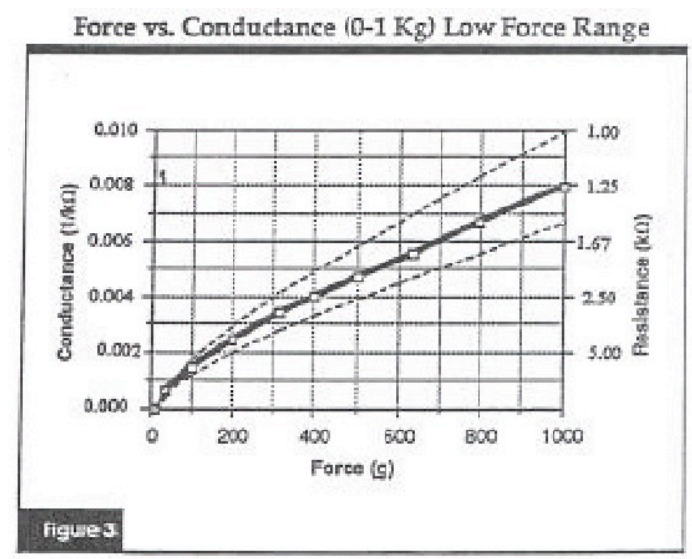
For a resistive polymer Velostat™ (from 3M), of thickness 70 µm and a specific resistance of 11 kΩ/cm², resistance for pressures over 16 kPa can be approximated by

$$R = \frac{51.93}{p^{1.47}} + 19.$$

FSR Characteristics

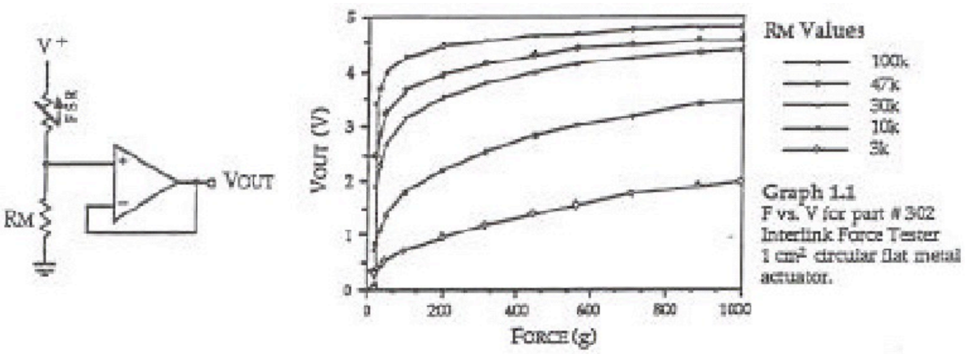




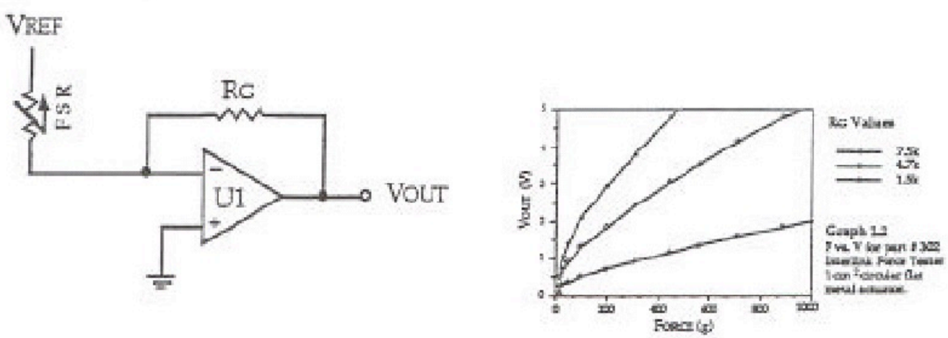


- 3-4 decades of sensitivity, 0.01 - 100 PSI, hundreds of Ω to >10 Meg Ω
  - Depending on device & Manufacturer
  - "---" is part-part repeatability bound
    - Typically ±15% - ±25% for Interlink
  - Sensitive to temperature, humidity...

FSR Interface Circuits



Voltage Divider

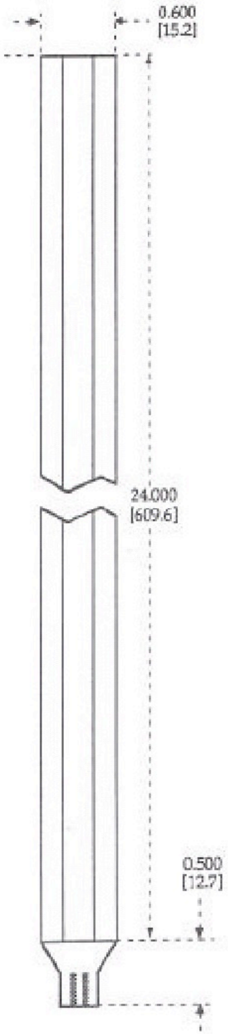


Current-to-Voltage

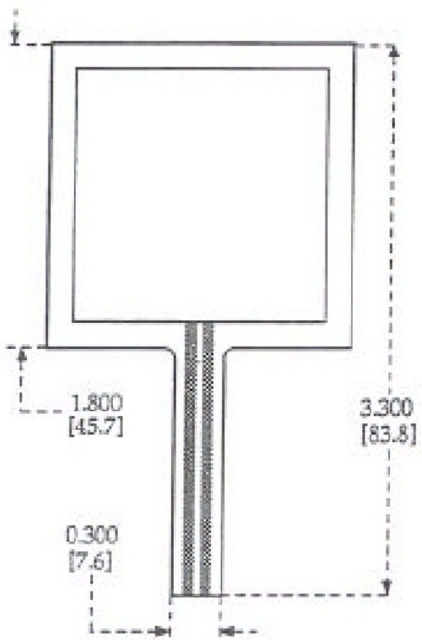
- Voltage Divider
  - Very nonlinear; switch characteristic
  - Only buffer needed
- Current Mode
  - Smoother range but (Less headroom)
  - Transimpedance amp

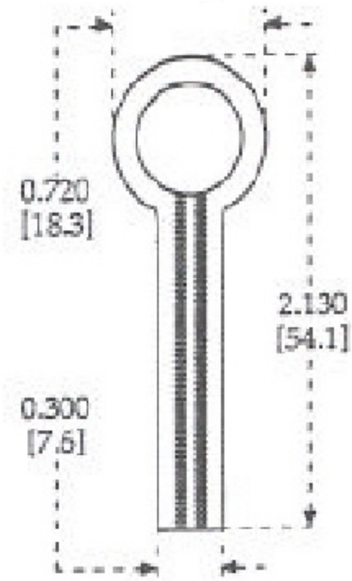
Many Shapes and Sizes

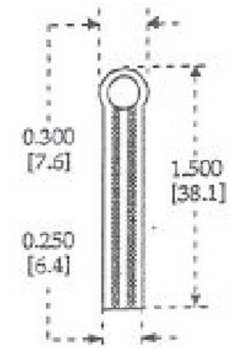
Part #408 (24" Trimmable Strip)



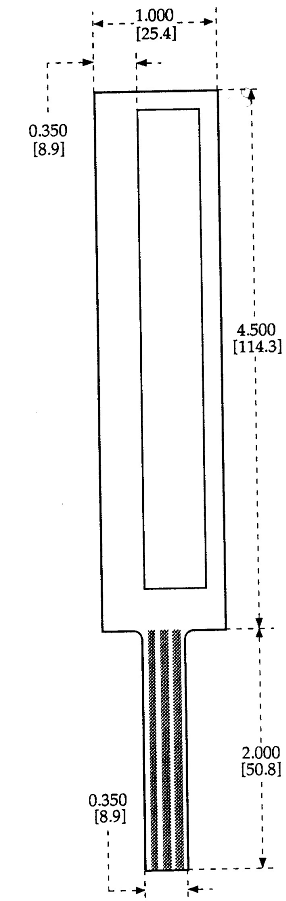
Part #406 (1-1/2" Square)





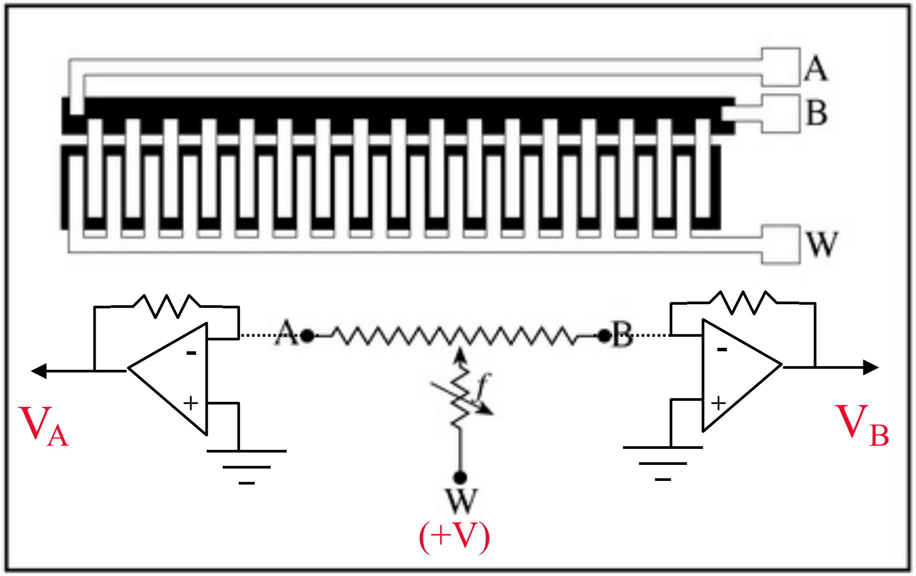


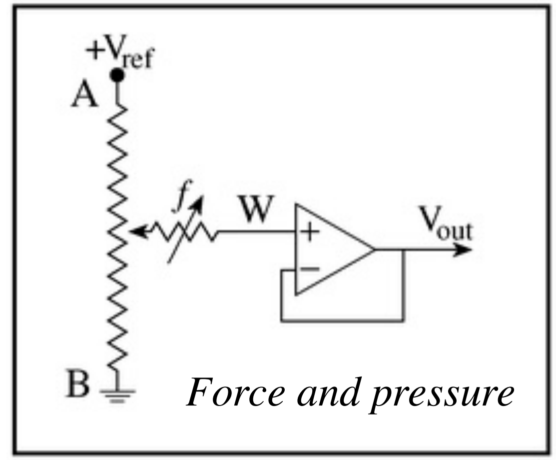
Part #360 (4" Linear Potentiometer)

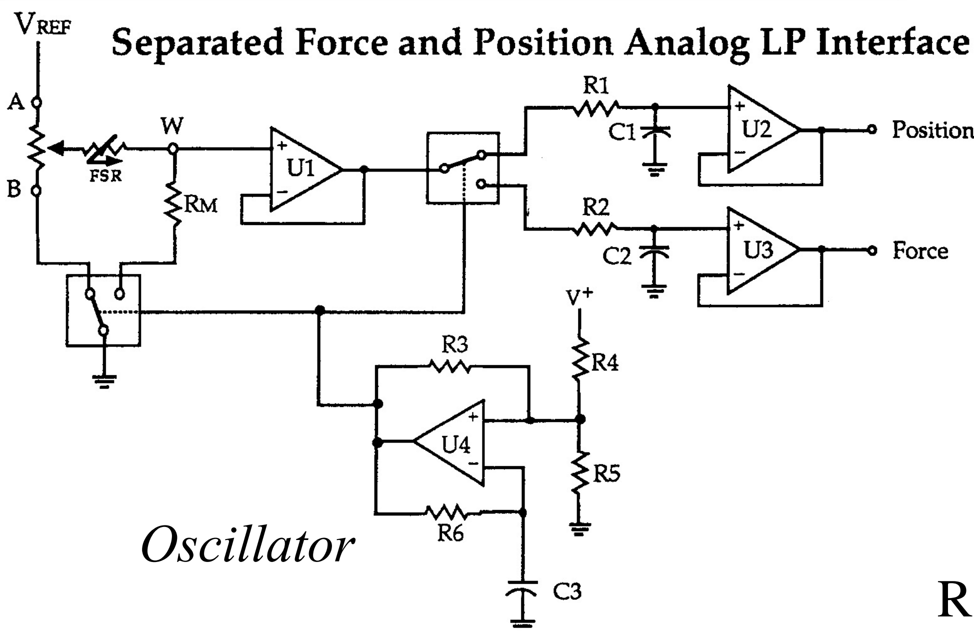


Various options from Interlink

The FSR Potentiometer







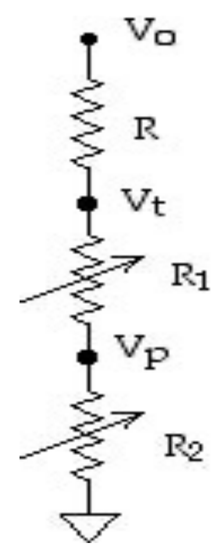
Can also inject voltage into W and have transimpedance amplifiers at A and B

Position is:

$(V_A - V_B)/(V_A + V_B)$

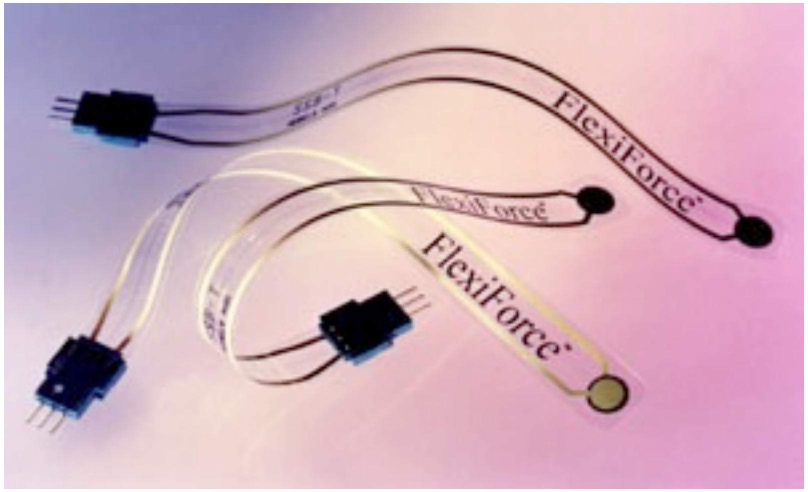
and Force becomes:

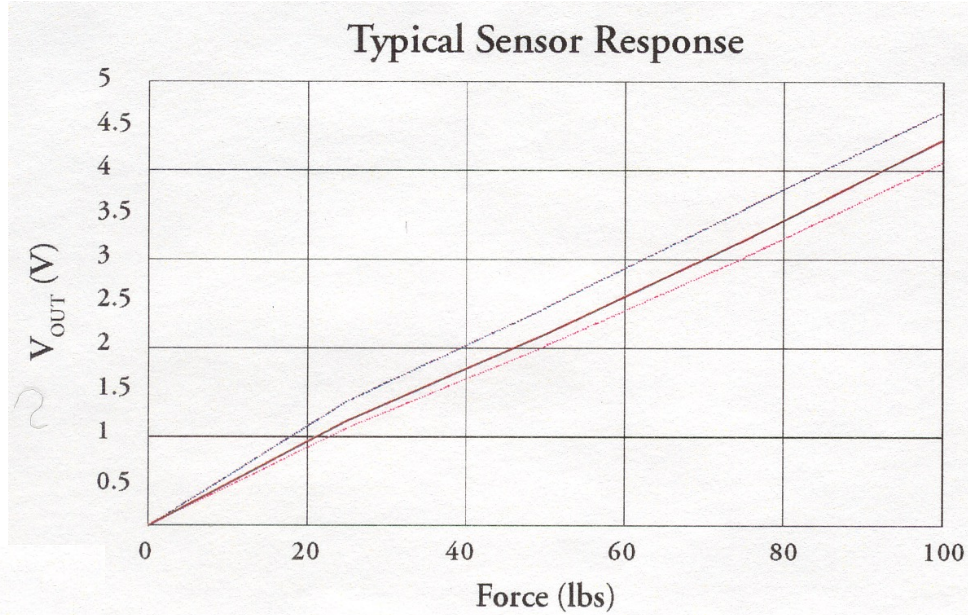
$V_A + V_B$



Ratiometric? From Rob Poor?

The FlexiForce (from TekScan)



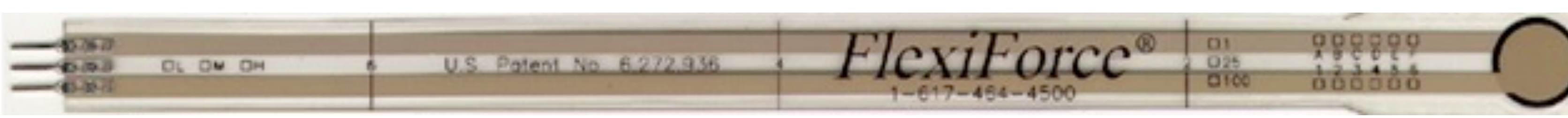


Performance

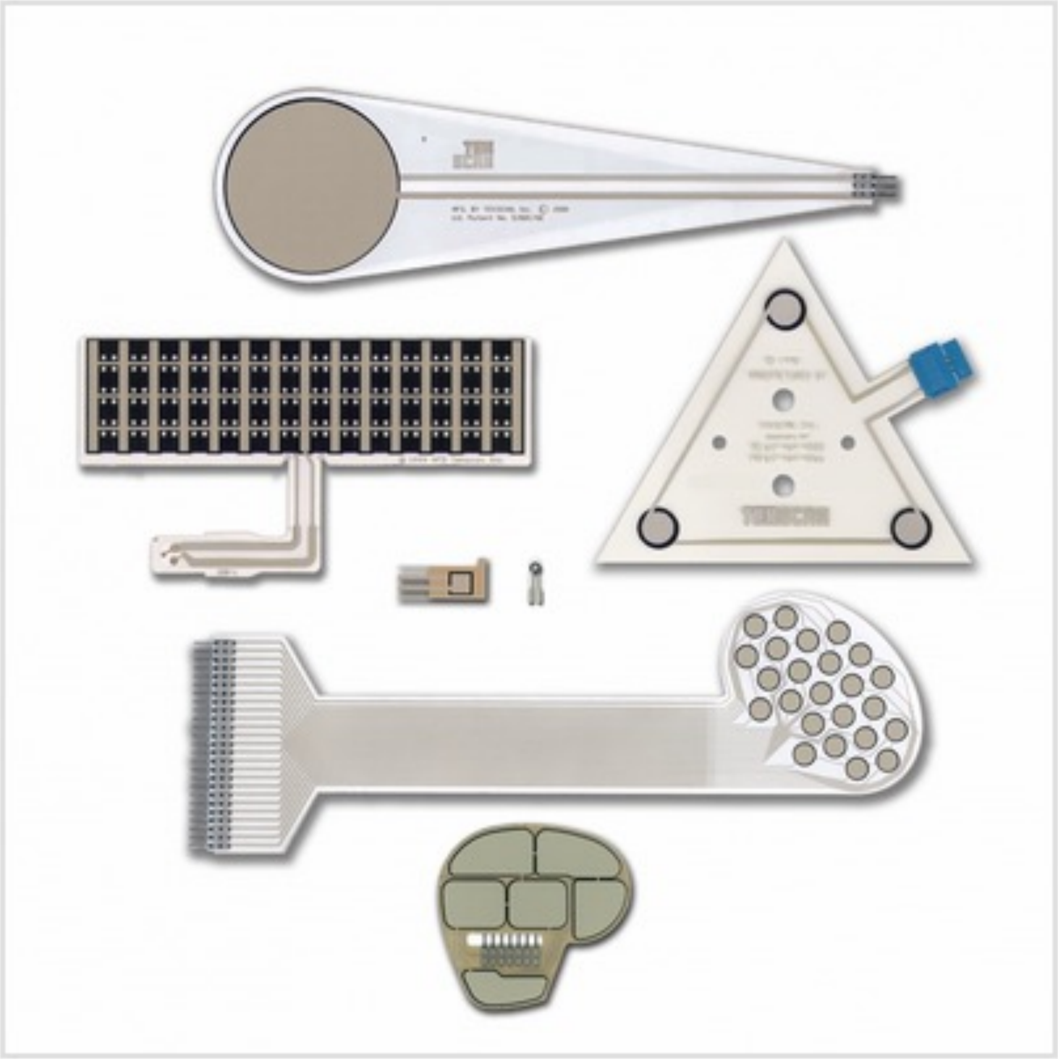
Linearity (Error)	< ±5%
Repeatability	< ±2.5% F.S.
Hysteresis	< 4.5 % F.S.
Drift	< 3%/ Logarithmic Time
Rise Time	< 20 µsec

Typical Response

Force Ranges	1 lb. (4.4 N)
	25 lb. (110 N)
	100 lb. (440 N)
	500 lb. (2200 N)
	1000 lb. (4400 N)

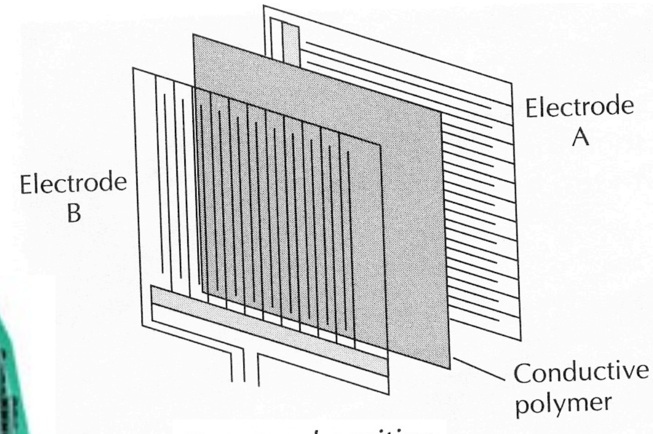


FlexiForce can customize (printing!)



https://www.tekscan.com/flexiforce-load-force-sensors-and-systems

Other Players - TekScan - FSR imaging matrices



Force and position sensing resistor pad/tablet.

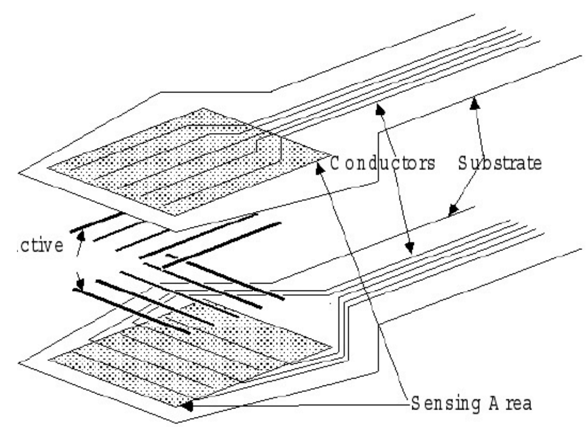
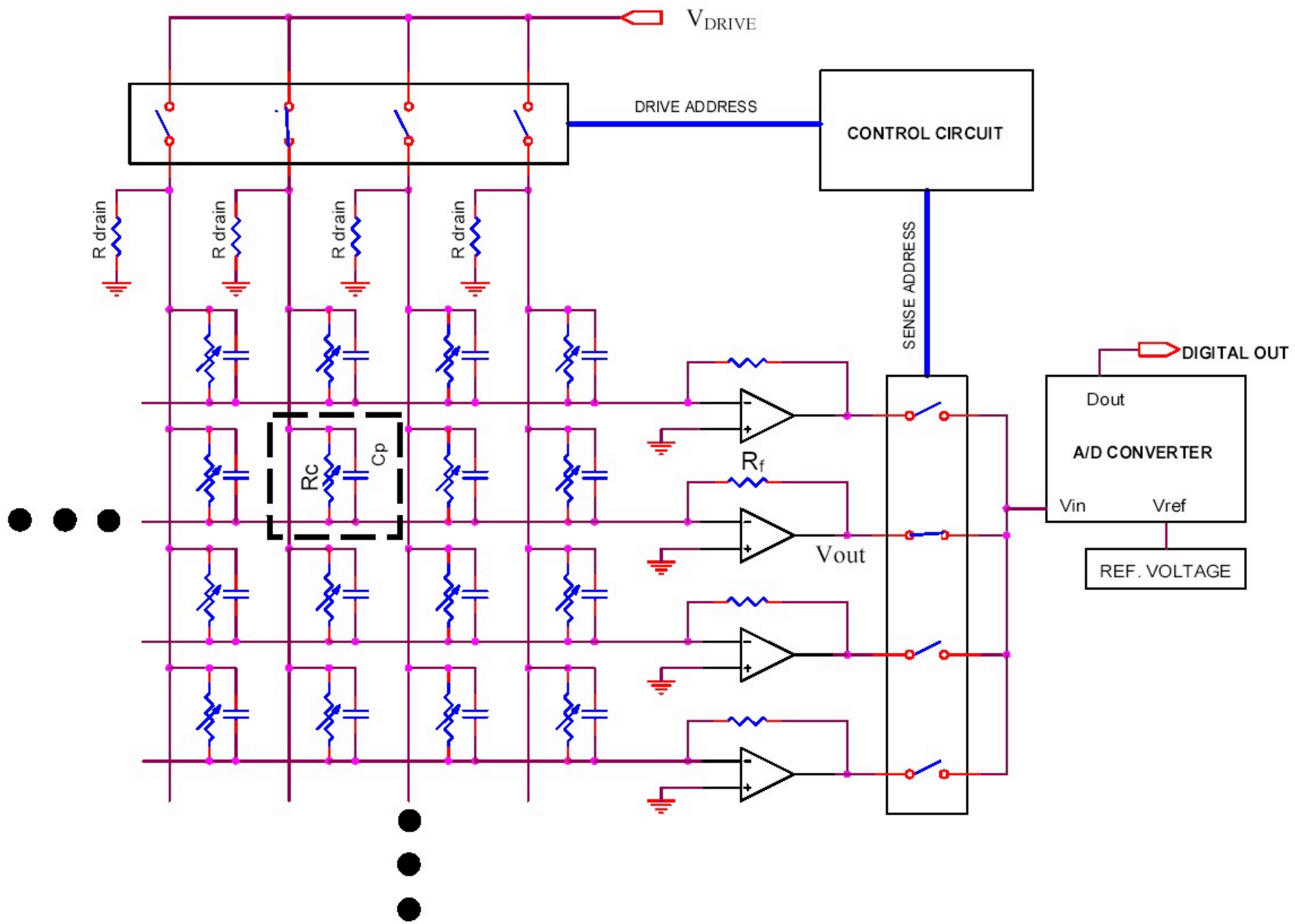


Figure 1. Smart Skin Structure

Papakostas, T. et al, 'A Large Area Force Sensor for Smart Skin Applications' IEEE Sensors 2002

Drive Electronics - row/column



Tekscan Specs

Table 1. Specifications of Representative Tactile Sensors

	Human Skin [i]	Fingerprint Imaging Sensor [vii]	Smart Skin
Resolution (mm)	2	0.1	0.1-10
Sensor Area (mm^2)	25x25	13x20	10^2–10^7
Number of Sensels	10^2	~10^4	10^2–10^6
Sensel Force Range (N)	0.4-10	switch	0.05-100
Linearity	Moderate	-	High
Hysteresis	Low	-	Very Low
Compliance	Yes	No	Yes
Bandwidth (Hz)	100	~10	100
Operating Temperature (°C)	-20 to 60	-10 to 45	-40 to 100

Robustness?

Force Imaging

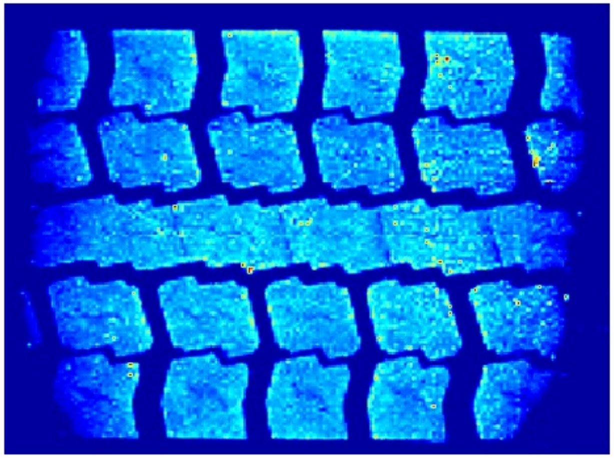


Figure 3. Pressure image of a tire

Car driving over force imaging plate

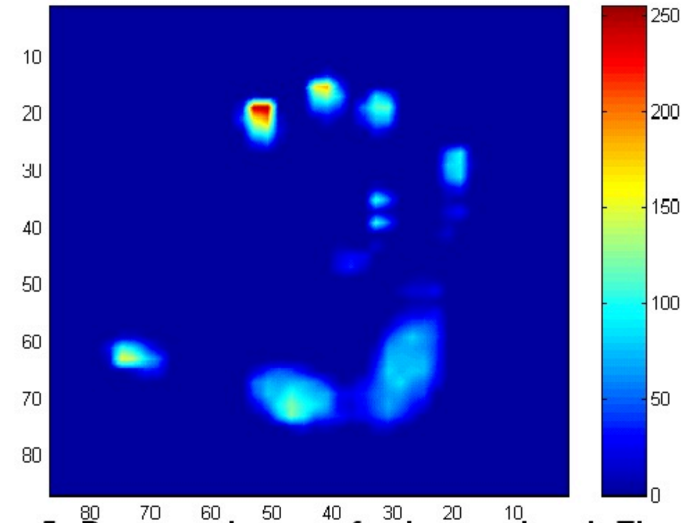
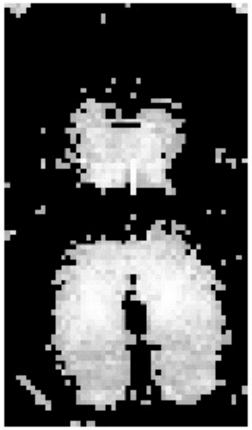


Figure 5. Pressure image of a human hand. The scale on the colorbar represents the amount of force in arbitrary units.



Hong Tan, Purdue

They do chair seats and beds too…

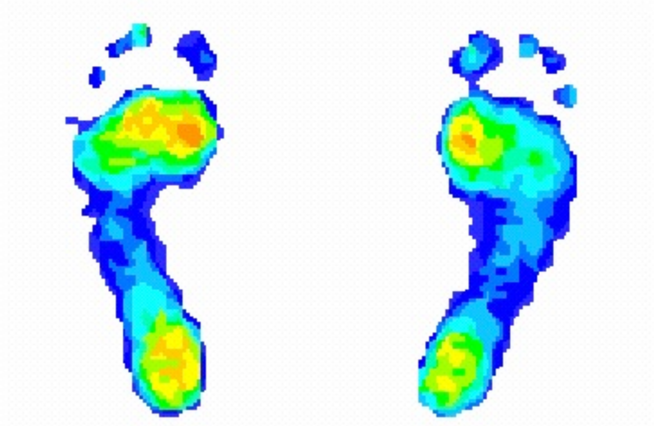
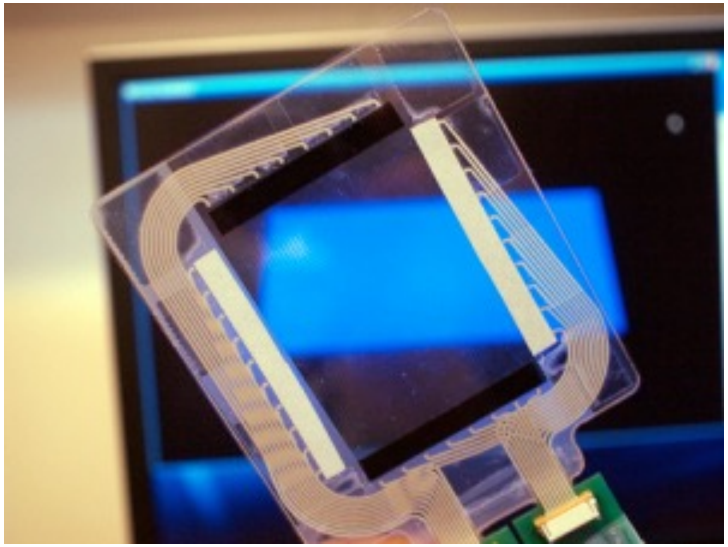


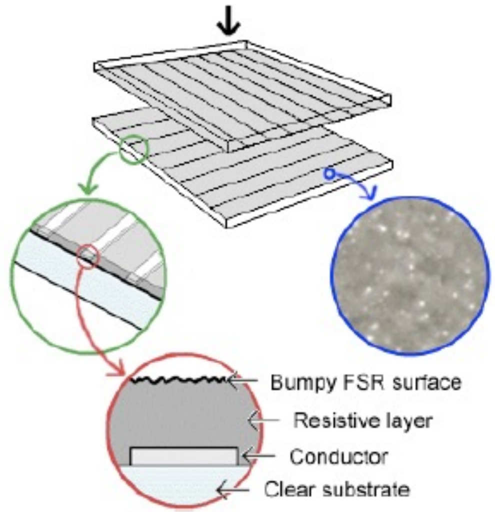
Figure 4. Ordinary pressure distribution of feet

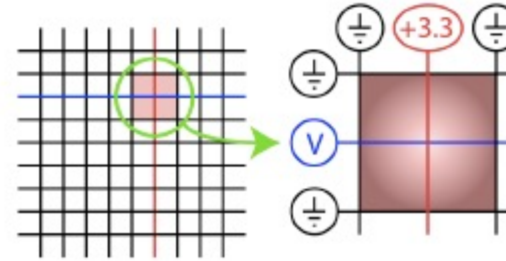
Ken Perlin/NYU make transparent "interpolating" FSRs

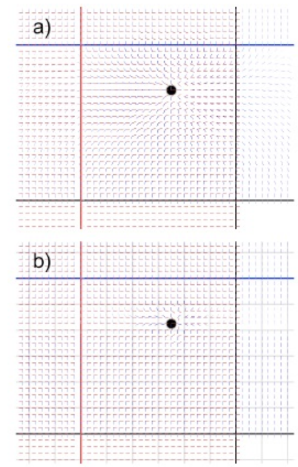
Load
Refresh
Play
Stop
Mask value
Smart Filter
Equilibration Point
Mean
Std Dev
CV
131.712
21.5283
16.3455
COF
XY
Vector
112
/200

NYU's (Perlin Group) FSR Touchscreen

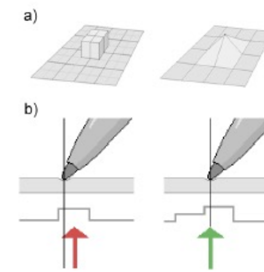








Drone Wires Improve Linearity



- TouchCo (bought by Amazon)
- iFSR (interpolating FSR) matrix
  - Like a Tekscan sheet w.clear ITO electrodes and transparent(?) FSR ink
- Measures & locates pressure – row/column multitouch readout (ground unused electrodes)
- Interpolating… (helps quantization error)
- See SIGGRAPH 2009 paper:
  - Rosenberg & Perlin, "The UnMousePad: an interpolating multi-touch force-sensing input pad"

QTC Pressure Sensors

- Made by Peratech in the UK
- Quantum Tunneling Composites
- Metal-filled polymers, no direct conductive path
  - Current flows via quantum tunneling (AC readout w. capacitance?)
  - More tunneling (hence current) with more pressure
  - No zero-point deadband, smoother response, more durability (maybe)

SPECIFICATIONS

	QSRC025050	QSRC025130	QSSC025400
Dimensions			
Form Factor	Circular	Circular	Square
Active Area	5mm	13mm	40mm
Lead Length	35mm	35mm	35mm
Thickness	1mm	1mm	1mm
Electrical			
Stand-off resistance[1]	10^8 ohms	10^8 ohms	10^8 ohms
Force sensitivity range[2]	0 N - 100 N	0 N - 100 N	0 N - 100 N
Part-to-part force repeatability[3]	±10%	±10%	±10%
Single part force repeatability[3]	±2%	±2%	±2%
Force resolution	0.5%	0.5%	0.5%
Max current	100μA/cm²	100μA/cm²	100μA/cm²
Environmental			
Temperature Range	-30°C to 100°C	-30°C to 100°C	-30°C to 100°C
Humidity	0% - 100%	0% - 100%	0% - 100%
Lifetime	> 1M cycles at 10N	> 1M cycles at 10N	> 1M cycles at 10N

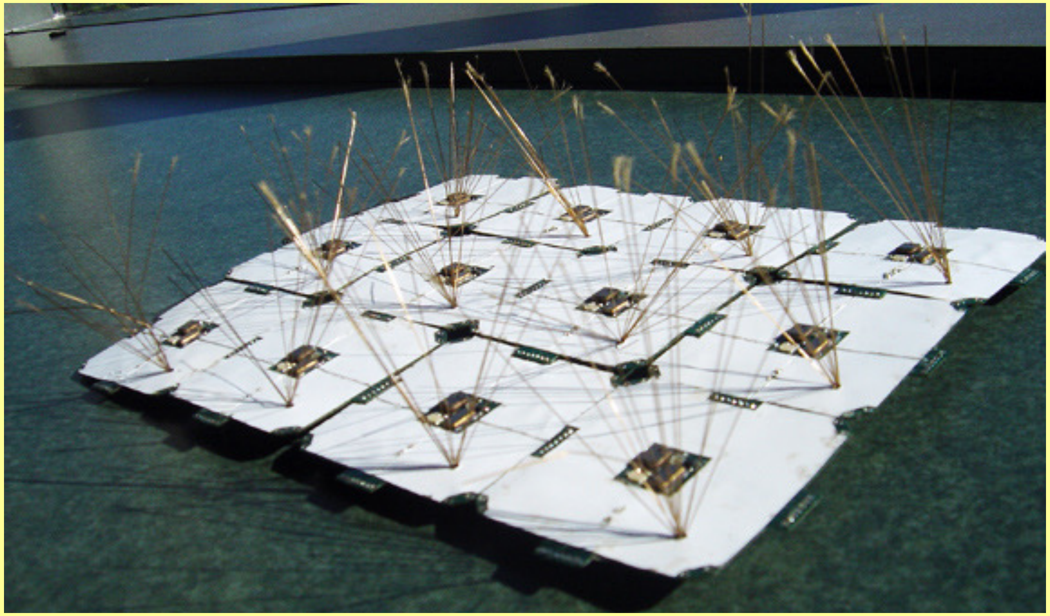
1. Unloaded, unbent
2. Dependent on mechanics
3. With repeatable actuation system

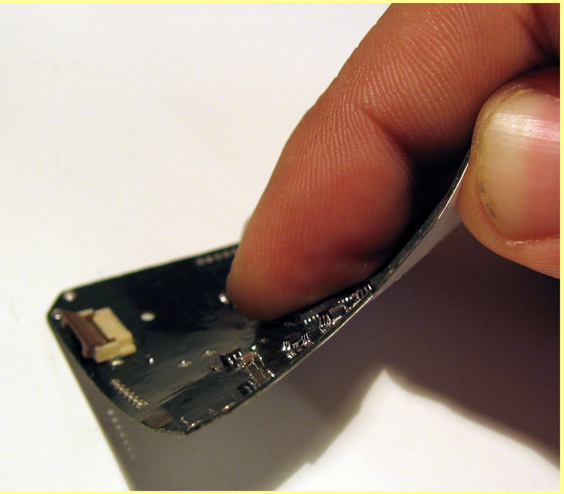
Many form factors (buttons, cables, etc.)

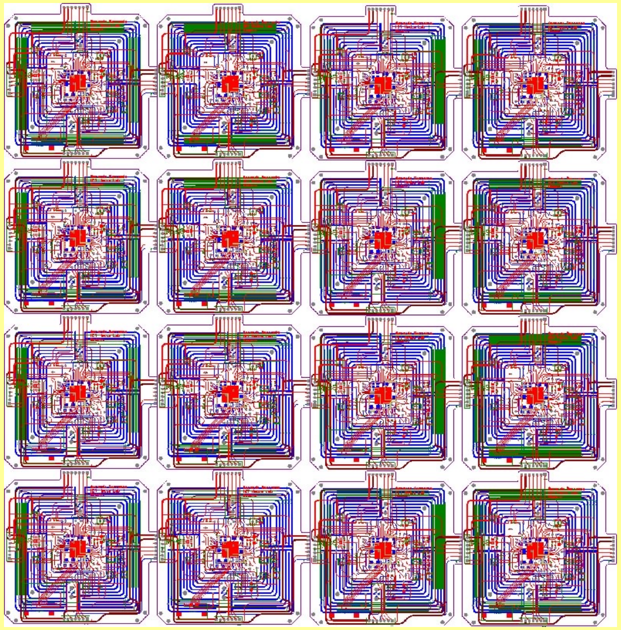
SENSING PERFORMANCE

http://www.practicalphysics.org/go/Resources_18.html

Sensor Net Array, Kapton Embedded (SNAKE) Skin





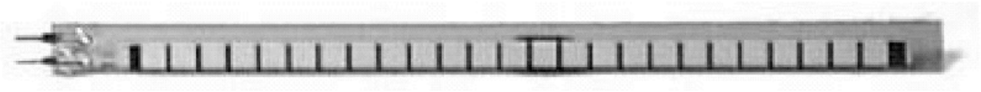


- **All on flex**
- Embedded strain gauges
- Covered by a layer of QTC pressure-measuring material
- Piezo whiskers
- Optical sensors, microphones, temperature
- Peer-Peer network
- High-Speed I^2C backbone
- ***Scalable!***

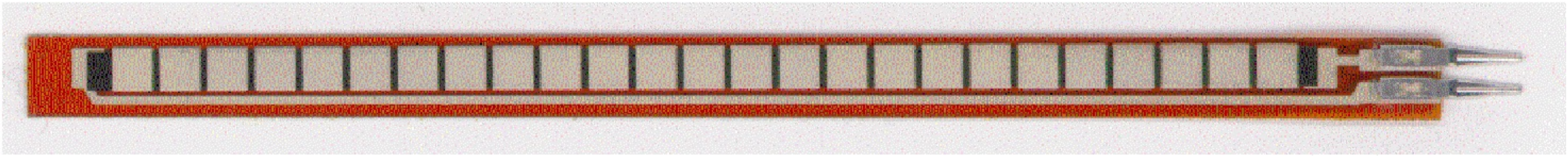
Jerry Barroeta-Perez

FSR Bendy Sensors

The Flex Sensor is a unique component that changes resistence when bent. An unflexed sensor has a nominal resistance of 10,000 ohms (10 K). As the flex sensor is bent the resistance gradually increases. When the sensor is bent at 90 degress its resistance will range between 30-40 K ohms.



The sensor measures 1/4 inch wide, 4 1/2 inches long and only .019 inches thick!

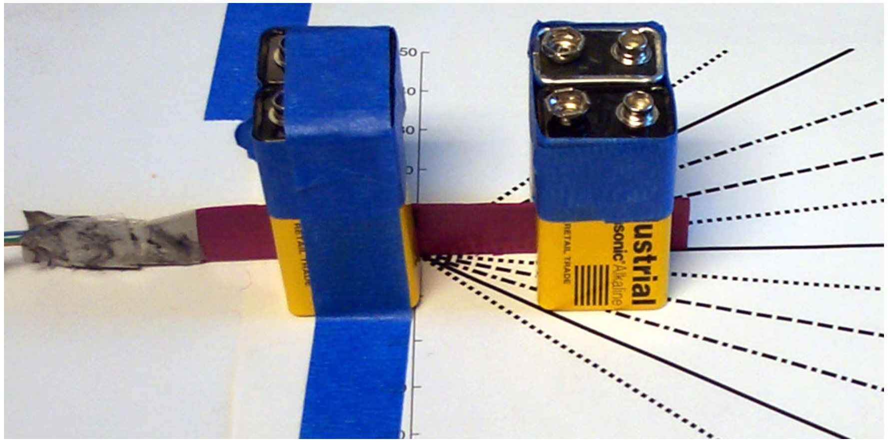


Available from the Images Co. (for PowerGlove - made by "Abrams-Gentile)

High-end versions made by Immersion for their CyberGlove
- 0.5° resolution, 1° repeatability, 0.6% max nonlinearity, 2-cm min bend radius

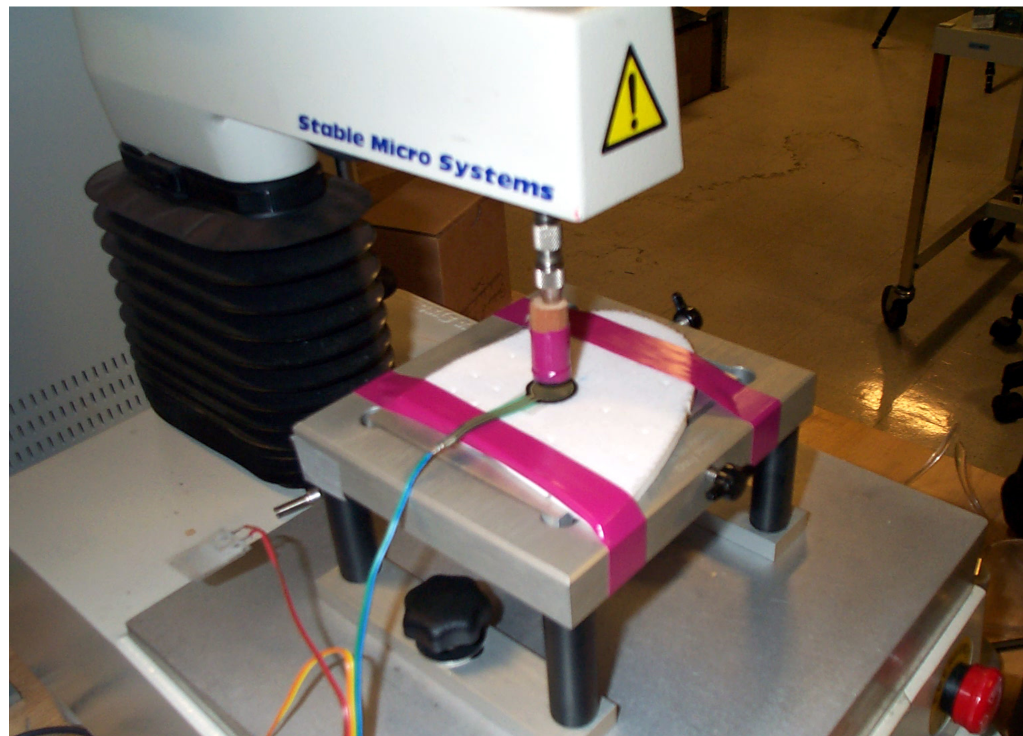
These only measure bend in one dimension (expanding the FSR's on surface)
- Conduction saturates quickly when contracted
- Can measure bidirectional bend with 2 FSR's back-to-back (and diff amp)

Resolution and Calibration Tests (from Stacy Morris ‘04)

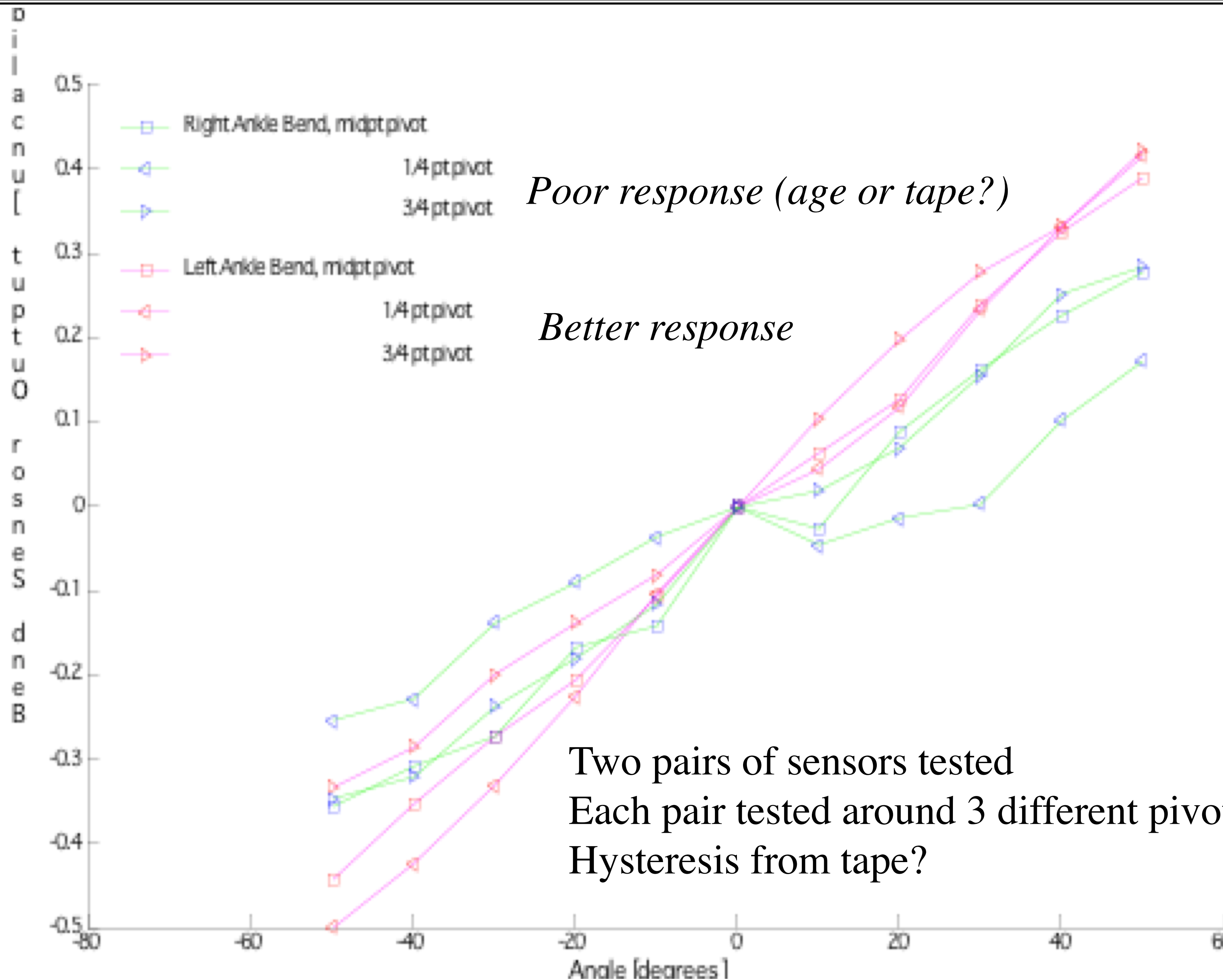


Bend Sensor calibration
Pin Bendy Sensor with Batteries and bend according to printed protractor

FSR calibration
Apply known pressure via rubber bumper with materials tester

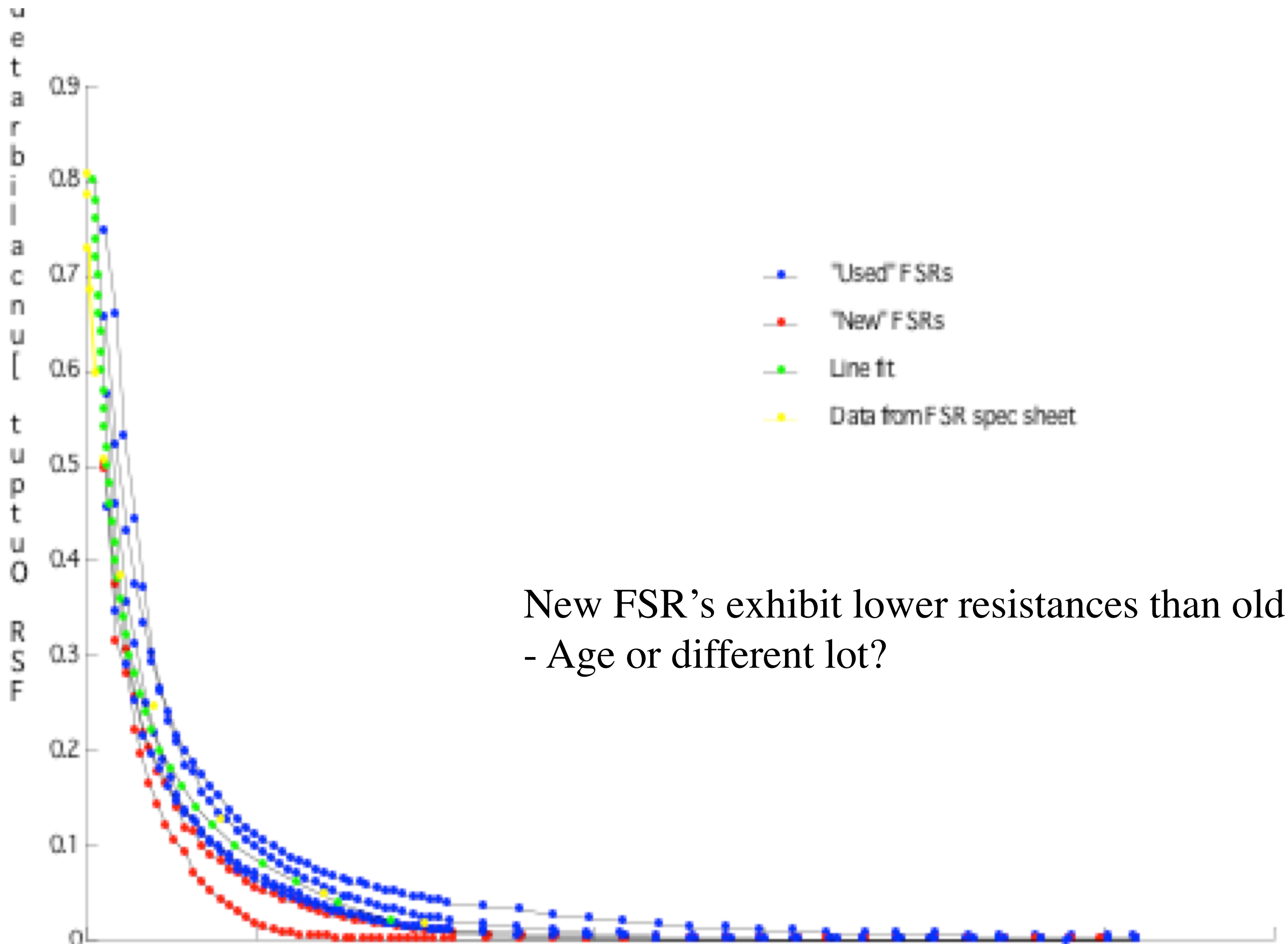


Abrams-Gentile (used) Bend Sensor Pairs into differential amp for bidirectional bend sensing



Two pairs of sensors tested
Each pair tested around 3 different pivot points
Hysteresis from tape?

FSR Response (voltage divider excitation)



New FSR's exhibit lower resistances than old ones
- Age or different lot?

Stretchy FSR “strain sensors”

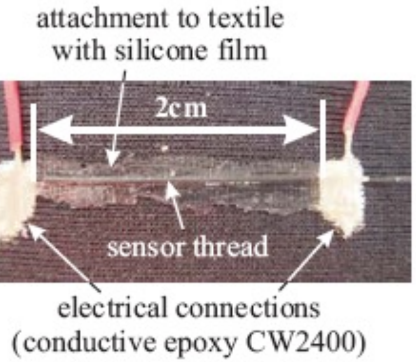


Figure 2. Sensor thread attached to the textile with a silicone film.

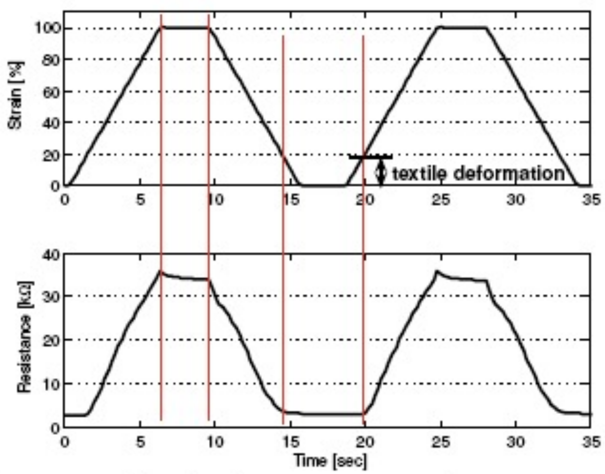
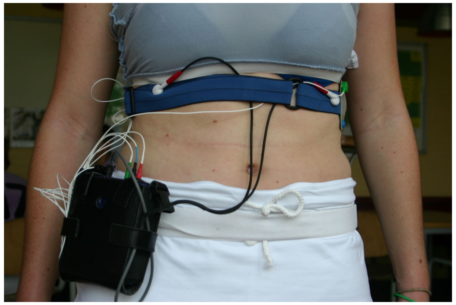
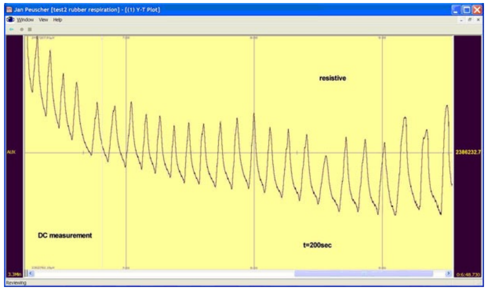


Figure 3. Typical response of sensor to a given strain (sensor length 2cm).

Recognizing Upper Body Postures using Textile Strain Sensors
Corinne Mattmann, Oliver Amft, Holger Harms, Gerhard Tröster, and Frank Clemens (ETH Zurich) - Proc. Of ISWC 2007

“A novel strain sensor was used which was developed by EMPA, Switzerland [12]. The sensor thread consists of a commercial thermoplastic elastomer (TPE) filled with 50wt-% carbon black powder and changes resistivity with length. It is fiber-shaped with a diameter of 0.3mm and has, therefore, the potential to be fully integrated into textile. In this prototype setup, the sensor was attached with a silicone film (see Fig. 2) which enables a measurement range of 100% strain. The length of the sensor was chosen to be 2cm.”





TMS International - breathing belts (resistive)
http://www.tmsi.com

More on fabric-compatible sensors in Bio Lecture…

Merlin Stretch Sensors…

Merlin Stretch Sensor

⊕ enlarge

The Merlin Stretch Sensor uses the latest 'Smart' material technology to give a uniquely flexible sensor, that can literally take measurements bent around corners or be woven into fabric.

- Flexible sensor, bends around corners!
- Small form factor - 2mm Cord
- Economical

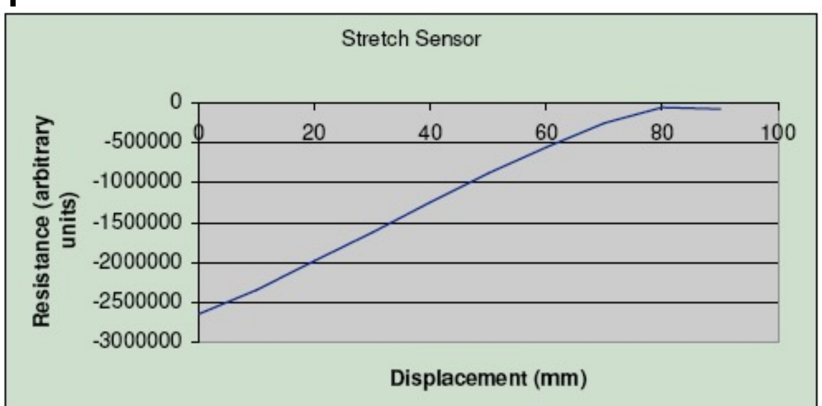
What is it?

The Stretch Sensor is a flexible cylindrical cord with spade electrical fixings at each end. The sensor behaves like a variable resistor, the more you stretch it the higher the resistance.

How does it work?

As the length of the Stretch Sensor alters so does it's resistance. For each centimeter of length change there is a resistance change of approximatly 400 Ohms/cm.

Comercial stretchy resistive sensor



http://www.merlinrobotics.co.uk

Images Company Stretch FSR

8" Flexible Stretch Sensor

Product code : **RB-Ima-15**

IMAGES
SCIENTIFIC INSTRUMENTS

Qty	Price
1 x	USD $14.95
10 x	USD $14.20
100 x	USD $13.49

Quantity : 1

Add to my cart

In Stock

ADD TO MY PREFERRED LIST

TELL A FRIEND

SHARE

Description

- 8" long flexible cylindrical cord
- Measures stretch, displacement and force
- Changes resistance when stretched

You may also be interested in

Bi-Directional Flexible Bend Sensor FLX-01-L (1K - 20K)

2" Flexible Stretch Sensor

12" Flexible Stretch Sensor

The **Images Scientific 8" Flexible Stretch Sensor** is a unique component that changes resistance when stretched. When relaxed the sensor material has a nominal resistance of 1000 ohms per linear inch. As the stretch sensor is stretched the resistance gradually increases. When the sensor is stretched to 150% of its original length (8" X 150% = 12"), its resistance will approximately double to 2.0 Kohms per inch.

The stretch sensor is a new way to measure stretch, displacement and force. The sensor is a flexible cylindrical cord with hook electrical terminals at each end. The sensor measures 8 inches long, not including the electrical terminals, and only .060 inches diameter!

Applications for the **Images Scientific 8" Flexible Stretch Sensor**:

- Virtual gloves and suits
- Robot exoskeletons

- Supplier code : STRX-08

Fabric Stretch Sensors

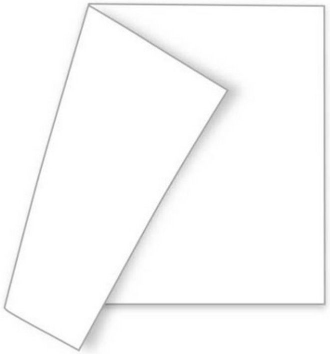
EEONYX

INQUIRE ABOUT THIS PRODUCT

NTEX STRETCHY SENSOR

LTT-SLPA

A conductive knitted nylon/ elastane fabric for applications requiring environmental stability and conformability to irregular shapes, such as pressure sensors.



CHARACTERISTIC	MEASURED VALUE
PART NUMBER	LTT-SLPA
COMPOSITION	72% Nylon, 28% Elastane
WEIGHT	163 g/m^2
THICKNESS	approximate .38 mm
SHEET RESISTIVITY	From 2K ohms per square to 100K ohms per square

http://eeonyx.com/products/ntex-stretchy-sensor/

Discontinued?

Fabric or soft strain gauges

- Weave changes resistance under strain

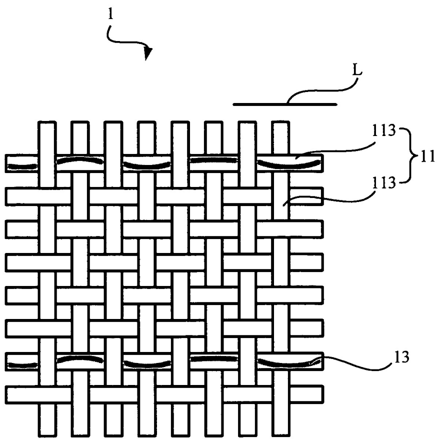
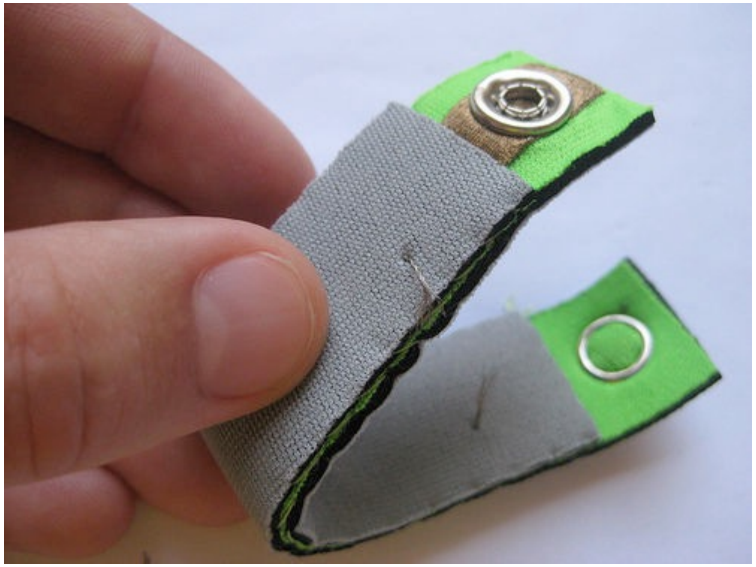


FIG. 1A



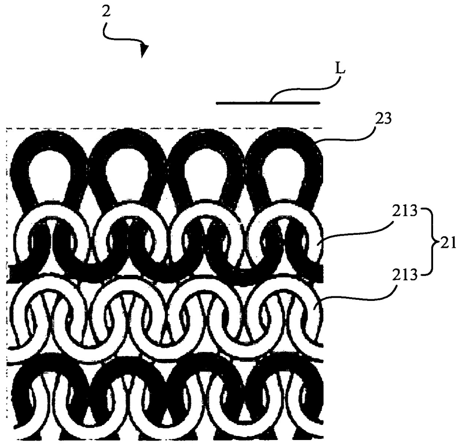


FIG. 1B

Instructables…

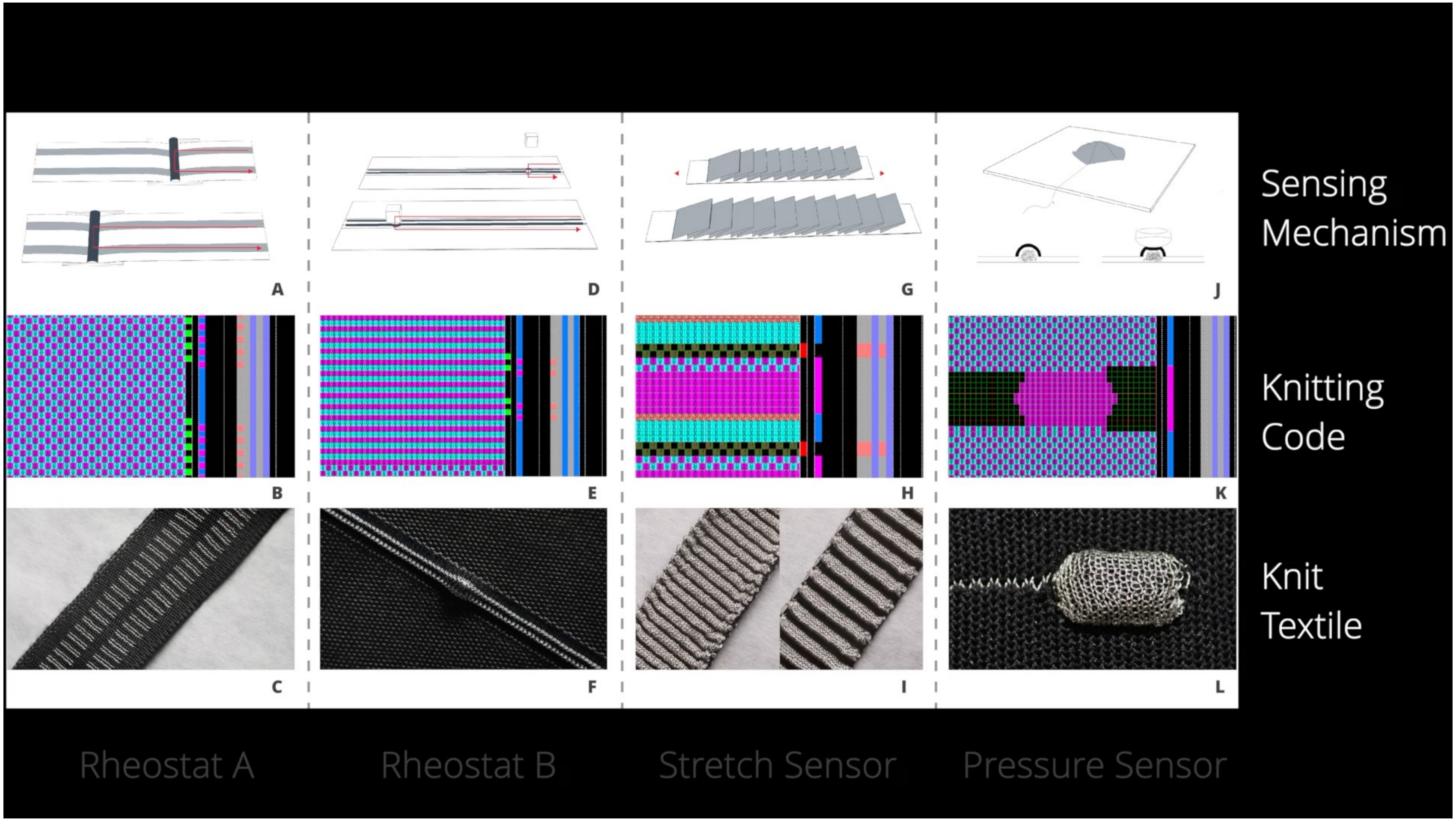
http://core.ac.uk/download/pdf/11308925.pdf

Special issues of IEEE Transactions on EMB,
IEEE Proceedings

Suggestions from Jie

- Hey Joe, Yeah, Hannah Perner Wilson's work is pretty relevant, for example:knit stretch sensor:
- http://www.kobakant.at/DIY/?p=1762
- neoprene bend sensor/strain gauge: http://www.kobakant.at/DIY/?p=20
- tape pressure sensor: http://www.kobakant.at/DIY/?p=429
- And on the left is a full list of sensor options--Jie

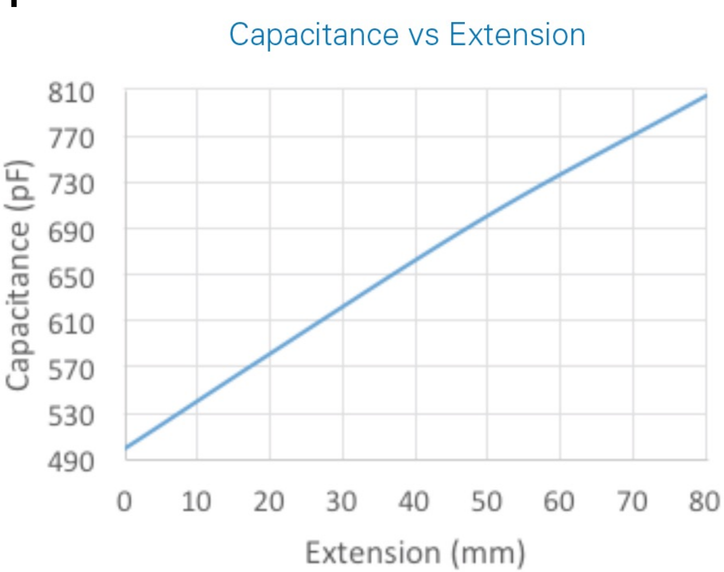
SensorKnits



Jifei Ou, Dan Oran, DonDerek Haddad

StretchSense Dielectric Elastomer Stretchy Capacitors

https://vimeo.com/user63099736



PARAMETERS	
Maximum Extension	200% strain
Average Capacitance (un-stretched)	365 pF
Average Sensitivity	2.8 pF/mm
Noise Level	0.67 pF

*These values are indicative of the sensors. Individual sensors may vary.

http://www.stretchsense.com

Papers on Stretch Sensors

http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1845861

http://www.nature.com/articles/srep03048

http://www.sciencedirect.com/science/article/pii/S0379677905007137

http://www.mdpi.com/1424-8220/8/6/3719

- From Irmandy

StretchyKeyboard:
Multi-sensory Fabric for Deformable Musical Interface

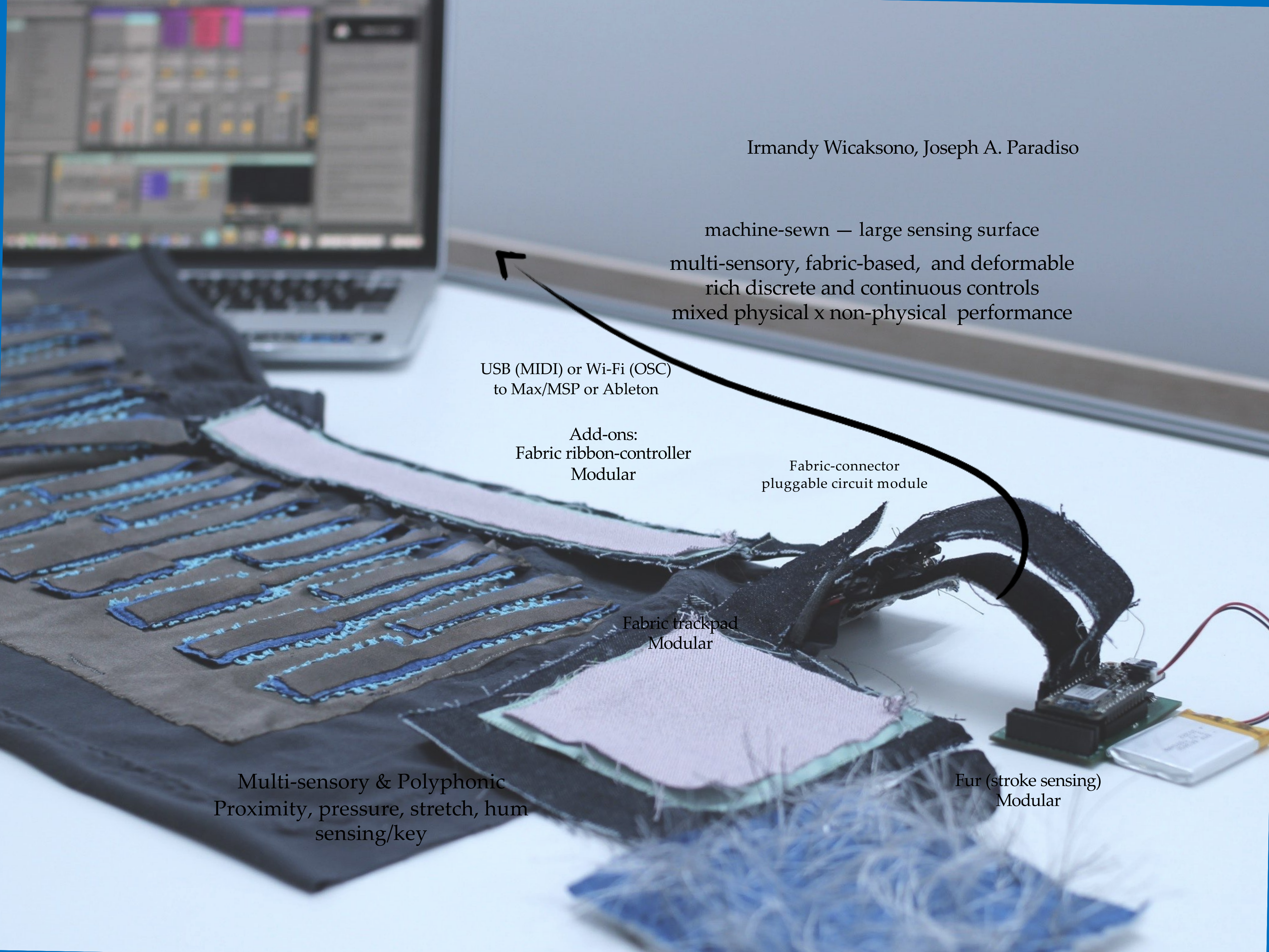
Irmandy Wicaksono
Prof. Joseph A. Paradiso

Responsive Environments
MIT Media Lab


Irmandy Wicaksono, Joseph A. Paradiso
mit media lab

Irmandy Wicaksono, Joseph A. Paradiso

mit media lab


Irmandy Wicaksono, Joseph A. Paradiso
machine-sewn — large sensing surface
multi-sensory, fabric-based, and deformable
rich discrete and continuous controls
mixed physical x non-physical performance
USB (MIDI) or Wi-Fi (OSC)
to Max/MSP or Ableton
Add-ons:
Fabric ribbon-controller
Modular
Fabric-connector
pluggable circuit module
Fabric trackpad
Modular
Multi-sensory & Polyphonic
Proximity, pressure, stretch, hum
sensing/key
Fur (stroke sensing)
Modular

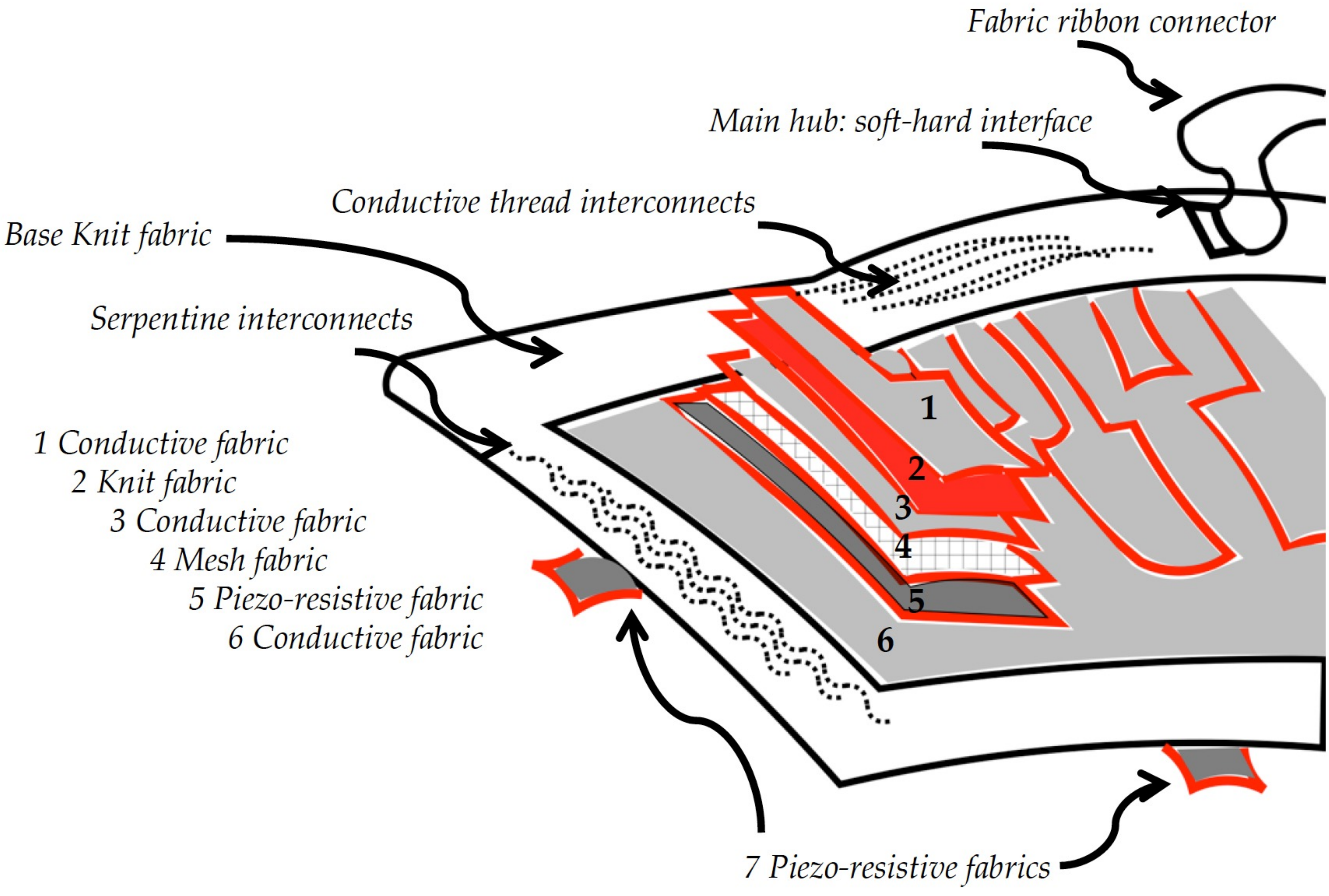


Figure 3.1: Textiles structure of the multi-modal fabric keyboard


A Tour of Live
Recording Audio
Creating Beats
Playing Software Instruments