Force-sensitive Resistor (FSR)

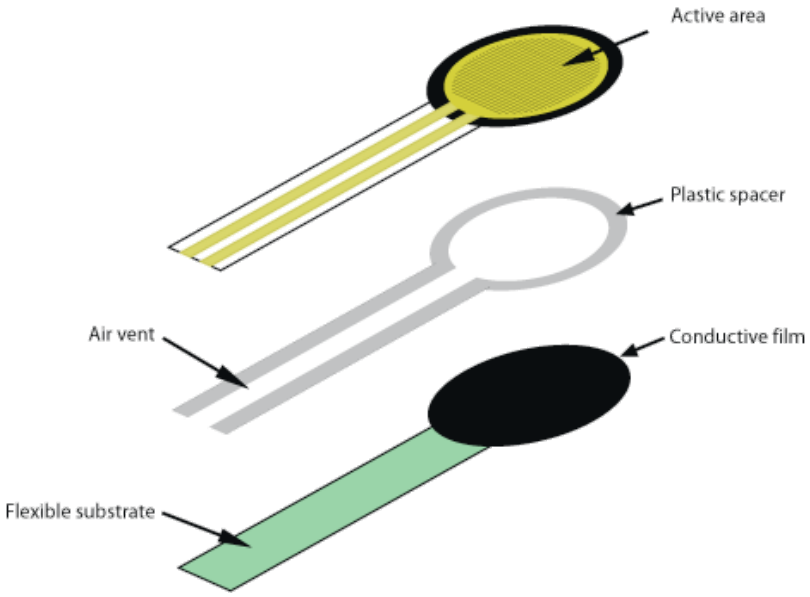
Summary

Introduction

A **force-sensitive resistor** (alternatively called a **force-sensing resistor** or simply an **FSR**) has a variable resistance as a function of applied pressure. In this sense, the term "force-sensitive" is misleading – a more appropriate one would be "pressure-sensitive", since the sensor's output is dependent on the area on the sensor's surface to which force is applied.

These devices are fabricated with elastic material in four layers, consisting of:

- A layer of electrically insulating plastic;
- An *active area* consisting of a pattern of conductors, which is connected to the leads on the tail to be charged with an electrical voltage;
- A plastic *spacer*, which includes an opening aligned with the active area, as well as an air vent through the tail;
- A flexible substrate coated with a thick polymer conductive film, aligned with the active area. This polymer is very often replaced by a layer of FSR ink.



When external force is applied to the sensor, the resistive element is deformed against the substrate. Air from the spacer opening is pushed through the air vent in the tail, and the conductive material on the substrate comes into contact with parts of the active area. The more of the active area that touches the conductive element, the lower the resistance. All FSRs exhibit a "switchlike response", meaning some amount of force is necessary to break the sensor's resistance at rest (approximately 1 MΩ), and push it into the measurement range (beginning at approximately 100 KΩ) (Interlink Electronics 2005).

Operationally, an FSR is very similar to a strain gauge, the main difference being that a strain gauge's backing deforms with the resistive element, while an FSR's does not. This fact is important to consider when mounting an FSR against a support, as discussed below.

The same applied force will result in a wider output swing in a FSR than a strain gauge. Strain gauges, however, have higher accuracy than an FSR. Depending upon the particular needs of the application, one may choose one or the other. Ultimately, a major consideration in the choice of a sensor is cost; a major advantage of FSRs is their low cost.

Using an FSR

One of the most common circuits implemented to utilize an FSR's output is the voltage divider. A voltage (usually +5 V) is applied to one of the leads, while the other is grounded. FSRs are not polar, meaning it does not matter which side receives the voltage. One lead from a second resistor (with fixed value) is then

connected to the voltage side, while the other lead of the second resistor is also connected to ground. In this way the FSR is able to measure the "voltage drop across a resistor". The resistance value of the second resistor determines the output range of the sensor. Typically, 100 KΩ will yield a sensor output suitable for common ADCs used for musical applications.

Mounting

Because the FSR's operation is dependent on its deformation, it works best when affixed to a support that is firm, flat, and smooth (Burdea 1994). Mounting to a curved surface (as is often the case when placing sensors on the body or clothing, especially on a dataglove) reduces measurement range and resistance drift. One solution is to use a sensor with a smaller active area, since less of the sensing area will be deformed by the contours of the body. Bending the tail will also affect performance because the air vent will be deformed. In cases where bending the sensor cannot be avoided, a preliminary calibration is strictly necessary to assure consistent results. Moreover the tail is also relatively fragile, and if bent far enough the conductive leads inside it will break, rendering the sensor useless and difficult to repair.

Output

The FSR's output signal is a monotonic function of area and pressure. When enough force is applied,this function changes slope quickly due to sensor saturation. After this point output will not be significantly affected by an increase in applied pressure.

This sensor is known to have poor accuracy, with errors up to 25% of output (Burdea 1994) but can be a good choice if only qualitative measurements are needed.

History

The FSR was invented by Franklin Eventoff in 1977 as an attempt to make digital instruments more expressive. Early instruments include the Sonica [http://matrixsynth.blogspot.com/2007/07/sonica-serge.html] and Mattel's Magical Musical Thing [http://www.youtube.com/watch?v=ywz7vN0GF_Y]. In 1985 Eventoff founder and CEO of Interlink Electronics. He has left interlink and has started a new company called Sensitronics.

Devices

Prices listed below are updated to March 2011

Interlink Electronics FSR

Description: Force Sensing Resistors
Datasheet: FSR Integration Guide and Evaluation Parts Catalog
Resources: nice spec summary from Robotshop
Notes: Prices vary depending on the size and shape of the sensor. See also the "FSR Design Kit."
Variants: There are four formats: 0.2" and 0.5" diameter circular, 1.5" x 1.5" square, and 24" long strip

Sources

- Interlink Electronics [http://www.fsrlink.com/]
- Robotshop [http://www.robotshop.ca/]
- Trossen Robotics [http://www.trossenrobotics.

Interlink Electronics FSR Design Kit

Description: Contains 4 FSRs of each of the four models: Model 400, 402, 406 and 408 sensors, as well as overlays and adhesives, FSR Integration Guide, Evaluation Parts Catalogue, Technical Notes and Suggested Interface.

Sources

- Interlink Electronics [http://www.fsrlink.com/]

Datasheet: FSR Integration Guide and Evaluation Parts Catalog
Resources: nice spec summary from Robotshop
Notes: Great kit for beginners, except for the waste from the limited range of sizes available!
Variants:

Sources
- US$100
- Robotshop [http://www.robotshop.ca/] CAN$140.26

Tekscan FlexiForce sensors

Description: FlexiForce sensors family. Resistive Force Sensor
Datasheet: Flexiforce User Manual
Resources:
Notes:
Variants: A201 MODEL; HT201 (HIGH-TEMP) MODEL; A401 MODEL

Sources
- Tekscan [http://www.tekscan.com/flex force-sensors] US$99 for the starter kit.

Infusion Systems TouchMicro-5 v1.2

Description: Zero-travel force sensitive resistors.
Datasheet: Product web Page
Resources:
Notes:
Variants: Lots of variants according to the size, length of the tail and smoothness of the response. All the members of the *Touch* family share the same technology. Price varies according to the size.

Sources
- Infusion Systems [http://infusionsystems.com/] US$48.

Sensitornics Force Sensing Resistors

Description: "The Original Force Sensing Resistors"
Datasheet: Technical informations
Resources:
Notes:The Force-Sensing Resistor are available in both *Shunt Mode* and *Thru Mode*
Variants: Force-Sensing Resistor; Translucent FSR; Clear FSR

Sources
- Sensitronics [http://www.sensitronics.com] Unknown price

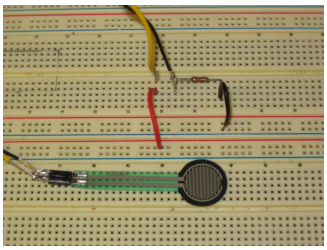
IEE, formerly LuSense

Description: Force Sensing Resistor (FSR)
Datasheet: N/A
Resources:
Notes:The information on the website of the company are very vague about the technical characteristics of the sensors. No datasheet is available.
Variants:

Sources
- IEE [http://www.iee.lu/] Unknown price

Media

Images



Videos

Infusions Systems TouchMicro sensor, using the I-CubeX controller and software interface.

External links & references

- G. Burdea, *Force and Touch Feedback for Virtual Reality.* New York, NY: Wiley, 1996.
- Interlink Electronics, 2005, "FSR Integration Guide & Evaluation Parts Catalog [http://www.sensorwiki.org/lib/exe/fetch.php?cache=cache&media=http%3A%2F%2Fwww.interlinkelec.com%2Fsites%2Fdefault%2Ffiles%2F94-00004A_FSR_Integration_Guide.pdf]", Company brochure, Camarillo, CA, 26 pp.
- FSR info at CNMAT [http://cnmat.berkeley.edu/sensor_module/interlink_force_sensing_resistor]

Sensor, FSR, Force, Resistance

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