

# Force Sensing Resistors

## An Overview of the Technology

Force Sensing Resistors (FSR) are a polymer thick film (PTF) device which exhibits a decrease in resistance with an increase in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices. FSRs are not a load cell or strain gauge, though they have similar properties. FSRs are not suitable for precision measurements.

### Force vs. Resistance

The force vs. resistance characteristic shown in Figure 2 provides an overview of FSR typical response behavior. For interpretational convenience, the force vs. resistance data is plotted on a log/log format. These data are representative of our typical devices, with this particular force-resistance characteristic being the response of evaluation part # 402 (0.5" [12.7 mm] diameter circular active area). A stainless steel actuator with a 0.4" [10.0 mm] diameter hemispherical tip of 60 durometer polyurethane rubber was used to actuate the FSR device. In general, FSR response approximately follows an inverse power-law characteristic (roughly  $1/R$ ).

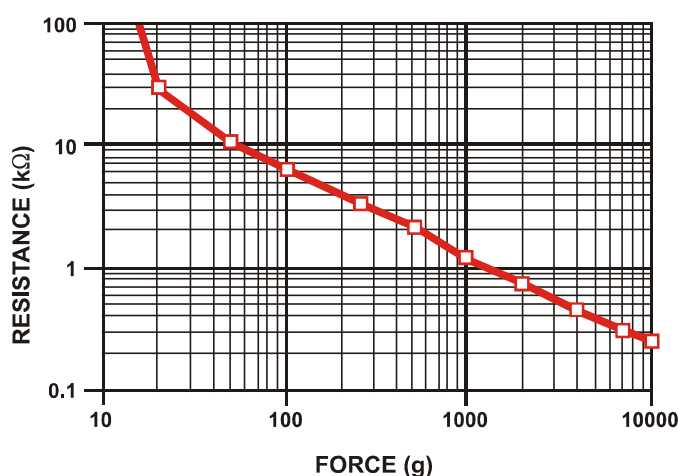


Figure 2: Resistance vs. Force

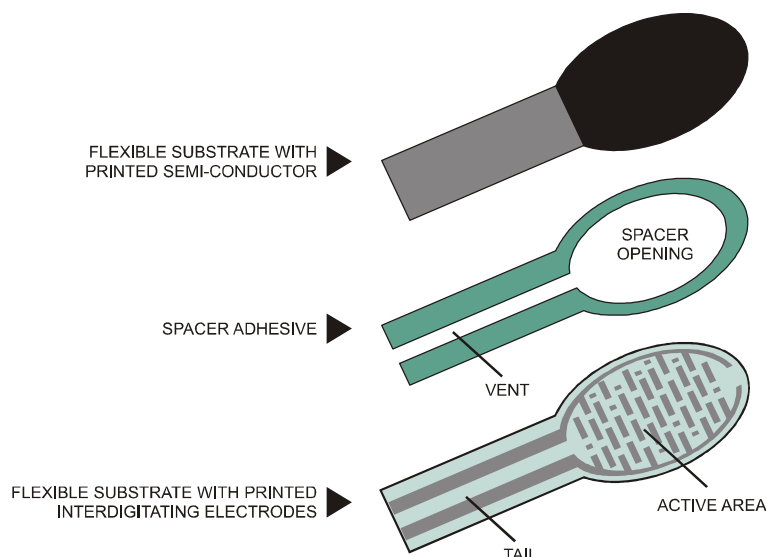


Figure 1: FSR Construction

Referring to Figure 2, at the low force end of the force-resistance characteristic, a switch-like response is evident. This turn-on threshold, or 'break force', that swings the resistance from greater than 100 kΩ to about 10 kΩ (the beginning of the dynamic range that follows a power-law) is determined by the substrate and overlay thickness and flexibility, size and shape of the actuator, and spacer-adhesive thickness (the gap between the facing conductive elements). Break force increases with increasing substrate and overlay rigidity, actuator size, and spacer-adhesive thickness. Eliminating the adhesive, or keeping it well away from the area where the force is being applied, such as the center of a large FSR device, will give it a lower rest resistance (e.g. stand-off resistance).

At the high force end of the dynamic range, the response deviates from the power-law behavior, and eventually saturates to a point where increases in force yield little or no decrease in resistance. Under these conditions of Figure 2, this saturation force is beyond 10 kg. The saturation point is more a function of pressure than force. The saturation pressure of a typical FSR is on the order of 100 to 200 psi. For the data shown in Figures 2, 3 and 4, the actual measured pressure range is 0 to 175 psi (0 to 22 lbs applied over 0.125 in<sup>2</sup>). Forces higher than the saturation force can be measured by spreading the force over a greater area; the overall pressure is then kept below the saturation point, and dynamic response is maintained. However, the converse of this effect is also true, smaller actuators will saturate FSRs earlier in the dynamic range, since the saturation point is reached at a lower force.

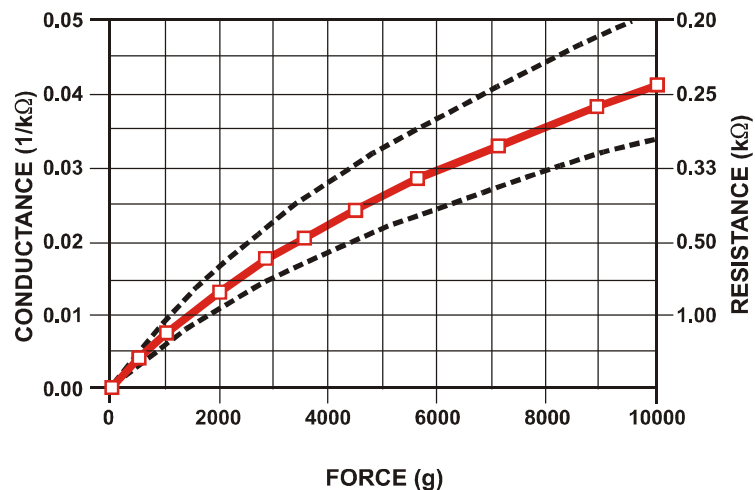


Figure 3:  
Conductance vs. Force (0-10Kg)

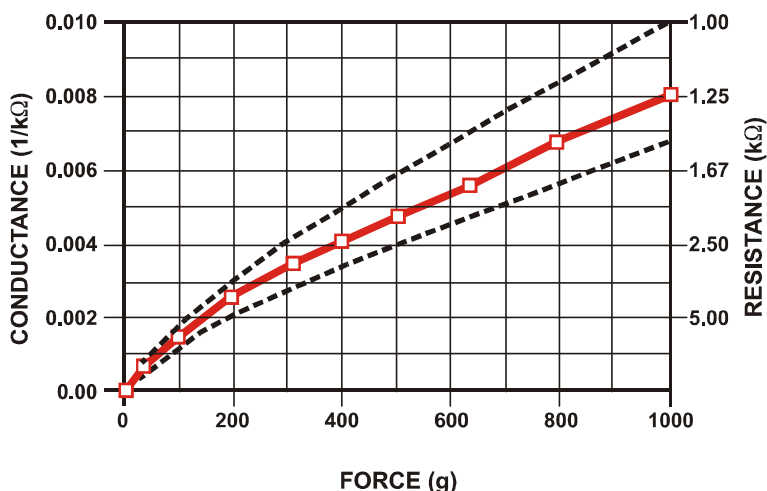


Figure 4:  
Conductance vs. Force (0-1Kg) Low Force Range

## Force vs. Conductance

In Figure 3, the conductance is plotted vs. force (the inverse of resistance:  $1/r$ ). This format allows interpretation on a linear scale. For reference, the corresponding resistance values are also included on the right vertical axis. A simple circuit called a current-to-voltage converter (see page 21) gives a voltage output directly proportional to FSR conductance and can be useful where response linearity is desired. Figure 3 also includes a typical part-to-part repeatability envelope. This error band determines the maximum accuracy of any general force measurement. The spread or width of the band is

strongly dependent on the repeatability of any actuating and measuring system, as well as the repeatability tolerance held by Interlink Electronics during FSR production. Typically, the part-to-part repeatability tolerance held during manufacturing ranges from  $\pm 15\%$  to  $\pm 25\%$  of an established nominal resistance.