[0092] 3. Auto Calibration & Preloading Compensation of Sensor Data

[0093] The nature of FSR sensors is that they are non-conductive without an applied force. In order for a sensor to be sensitive for small forces, the sensor must be pre-loaded. This required pre-loading force **90** is described in FIG. **11**, where the forces below 75 grams of force provides initially a very low voltage, then a irregular voltage output. As the applied force reaches the 75 gf area, the measured voltage becomes regular and consistent.

[0094] FIG. **12** illustrates how each individual sensor can be mechanically pre-loaded as a part of the sensor structure. A PMMA plastic housing **250** compresses **220** the FSR sensor **200**. Part of the pre-loading housing **250** is flexible at **240** in order for the sensor to register and measure any applied force **230**. For a commercial implementation, the compression force can be designed into the actual sensor **200** through compressing sensor material or even through the use of adhesive pulling the bottom and top parts of the sensor **200** tight together and thereby compressing the active FSR material within the sensor.

[0095] The impact on the touch screen system is that each of the FSR force sensors must be preloaded with a pre-loading force that will differ from sensor to sensor. One negative impact is that as material is aging in the sensor, the measured output will start to drift. For example, where the sensor is pre-loaded with 80 gram force and the sensor output is reset to 0V (interpreted as 0V by the software), over time there will be a change in the pre-loaded (the O-value) reading and it will no longer be 0V.

[0096] Other factors can also affect this O-value, for example, if the temperature rises and the material around the sensor expands, the force will increase, and the sensor reading will measure an actual sensor load value larger then the O-value (the specified pre-loading value).

[0097] Natural aging of the sensor material will also effect the sensor performance over time and the non loaded value will slowly drift away from 0V.

[0098] In accordance with the present invention, these characteristic of the FSR sensor are filtered out through a continuous auto calibration routine as seen in the functional block **16** of FIG. **7**. Specifically, the touch screen control software constantly runs a timer, and when the timer times out before any touch is registered, the last (or average of the last few) sensor reading(s) are used as the new O-value. This solution is described in more detail in FIG. **13**, which comprises the following steps:

[0099] At step **106** a Timer Algorithm detects when touch screen has not been touched for a predetermined amount of time. This initiates a calibration request;

[0100] At step **101** each sensor is polled and the readings are stored in a FIFO memory queue, or a running average is kept;

[0101] At step **103** each sensor's offset values are calculated per sensor calibration;

[0102] At step **102** each force sensor reading is corrected by subtracting the corresponding offset value from the sensor reading before using the reading for location calculation

[0103] The foregoing is repeated iteratively in runtime.

[0104] 4. Humidity Compensation of Sensor Data

[0105] Humidity causes a temperature dependency and sensor error similar to temperature as represented in FIG. **5**. Just as for the temperature compensation, the humidity curves can be compensated as shown in the functional block **16** of FIG. **7**, using the same type of software method used for the temperature dependence compensation as seen in FIG. **9** & FIG. **10**. The system will, however, need to employ the sensors to measure the humidity in order to apply the correct compensation curve.

[0106] Filtering of Sensor Data

[0107] In order to reach an optimal performance, the sensor data must be filtered for unintentional noise as shown in the functional block **16** of FIG. **7**. There are typically two components of noise impacting the performance: electrical noise and mechanical noise. Most of the electrical noise can be shielded out or filtered based on measured interfering noise in the system.

[0108] The mechanical "noise" is a function of both the sensors being too accurate as well as errors in the readings. In a system without filtering, this can be demonstrated by applying a constant force to a specific touch screen coordinate. The measured coordinate values will move slightly up and down, creating the illusion of jitter. This type of mechanical noise is typically filtered out through averaging the sensor data, for example, by employing a weighted moving average or exponential moving average.

$$WMA_m = \frac{np_m + (n-1)p_{m-1} + \ldots p_{m-n+1}}{n + (n-1) + \ldots 1}$$

[0109] 6. Material Calibration of Touchscreen

[0110] In order to fully compensate for all the different imperfections added to the total touch screen system due to the use of FSR sensors, it is also necessary to review the total mechanical stack-up.

[0111] FIG. **14** represents a touch screen system where the FSR sensor **161** is sandwiched between an activator **164** and a Poron™ backing **165**. The activator transfers part of the force applied to the touch screen lens **162**, and the Poron™ backing **165** supports the sensor **161** on the rigid cover **163**. The diverse components create a disjunctive transmission path for touch force running from the touch screen lens through the sensor **161** down to the cover **163** and this adds non-linear forces and other imperfections which impact the measured force. Moreover, materials such as adhesive between the different components and even dust can add further error into the total system performance. There is therefore a need to apply material compensation as shown in the functional block **16** of FIG. **7** in order to minimize the impact from these small yet unknown and non-linear forces. Note that this material compensation is applicable and appropriate for any force sensor based system independent of sensor type. This compensation is therefore applicable for not only FSR based sensors, but for Piezoresistive or Nanotech based force sensors as well.

[0112] The material compensation method applied herein uses a set number of coordinate points on the touch screen (3, 5, 9 or more) where a force is applied. The force may be applied by a tester unit, for example during manufacturing, or directly by the end-user pressing the points as they are displayed through the graphical user interface. An exemplary scenario with 9 calibration points is shown in FIG. **15**.

[0113] As pressure is applied at each point **174**, **177**, **178**, **179** and the actual is compared to the calculated position of the pressure. In addition, the different force levels are