[0063] The relationship between force F and voltage V can be quantified by equation (2):

$$F = k_2 \times d_{31} \times \frac{T}{W \times E \times L} \times V \qquad \text{eq (3)}$$

[0064] k_2: correction constant value

[0065] d_{31}: piezoelectric constant value

[0066] L: length of the actuator

[0067] T: thickness of the actuator

[0068] V: voltage applied to the actuator

[0069] E: longitudinal elastic coefficient

[0070] As illustrated in FIG. **4**, haptic device **300** can be used as a pressure sensor simply by sensing a voltage Vp generated by the displacement ΔY of member **306** caused by force F applied to the surface of surface **126**. In this way, by monitoring voltage Vp, haptic device **300** can be configured to act as an integrated haptic actuator/pressure sensor arranged to change operational modes (passive to active, and vice versa). In the passive mode, the haptic device **300** can act as a pressure sensor by sensing if voltage Vp is generated by haptic device **300** when force F impinges on member **306** according to equation (3). When (and if) the sensed voltage Vp exceeds a threshold voltage Vpth, then the haptic device **300** can changes modes from passive mode to active mode. In active mode, a haptic profile is used to direct a controller circuit to provide voltage V to member **306** (as shown in FIG. **3**) resulting in displacement ΔY creating the desired vibro-tactile effect on surface **126** in accordance with the selected haptic profile. In this way, haptic device **300** can considered an integrated pressure sensor/haptic feedback device that can be automatically switched back and forth between a pressure sensing device and a haptic feedback device.

[0071] Using the arrangements illustrated in FIGS. **3** and **4**, pressure information can be linked with haptic feedback. For example, vibro-tactile sensation can be increased with increasing pressure, and vice versa. Accordingly, when a user exerts increased pressure (i.e., presses harder) on a surface, the amount of vibration felt by the user increases thereby informing the user that they are pressing harder. In another embodiment, a touch event can be characterized as either a light touch event or a hard touch event. In this situation, different vibro-tactic sensations can be produced based upon whether the touch event is light or hard (or something in between). For example, a light touch may correspond to a situation where a user uses light touch pressure to slide their finger across a surface whereas a hard press may be when a user pushes down on the surface with greater pressure, such as a button click. In one example, a hard press initiates a selection and that results in a click vibration being produced while a light touch performs no selection but does provide notification to the user that the user is in a location suitable for making a selection. In another embodiment, a click off vibration can be performed when the user begins lifting off of the touch screen i.e., the lift out effect can be produced as the user is in the process of lifting off of the screen instead of immediately thereafter. These different touch events can be distinguished by providing multiple threshold levels or sequence of thresholds that can be used. For example, a light touch can correspond to a first threshold level whereas a heavy touch can coincide with a second threshold level, and so on. Moreover, a lift off event can be distinguished when a sensed voltage indicates that a corresponding applied pressure is decreasing over time.

[0072] FIG. **5** shows a flowchart detailing a process **500** for using a piezoelectric haptic actuator as both a pressure sensor and active haptic feedback device in accordance with an embodiment of the invention. Process **500** begins at **502** by sensing a node of haptic actuator **300**. If, at **504**, a voltage Vp is sensed, then the haptic actuator is in passive mode at **506**. In passive mode voltage Vp is being generated by force F applied to the haptic actuator member **306** in accordance with equation (3) and shown in FIG. **4**. At **508**, if the sensed voltage is determined to be greater than a threshold voltage value, then at **510**, the haptic actuator can be considered to be in active mode. By active mode, it can be understood to mean that the haptic actuator is now in a position to receive a voltage from a controlling circuit thereby causing haptic actuator to actively provide haptic feedback in the form of a vibro-tactile response created by haptic actuator member **306** (FIG. **3**). Once it is determined that the haptic actuator is in active mode, then at **512**, a haptic profile is retrieved from a haptic profile database. In the described embodiment, the haptic profile can be based upon any number of factors. For example, if the haptic actuator is associated with a button element of a graphical user interface, then the first threshold value can be indicative of an amount of pressure consistent with an intended pressing action by as user as opposed to a glancing touch not intended to be acted upon as a button press. At **514**, once the appropriate haptic profile has been retrieved, a controlling circuit applies an appropriate control voltage to the haptic actuator consistent with the haptic profile. In some cases, the haptic profile can vary depending upon the amount of pressure applied. If, at **516**, it has been determined that the haptic response is complete, then the haptic actuator is set to passive mode at **518** and control is passed back to **502**.

[0073] Additional embodiments of the present invention are presented in accordance with FIGS. **6-13**.

[0074] FIG. **6** shows display device **112** displaying representative haptic active GUI elements in accordance with an embodiment of the invention. It should be noted that although only a small number of all possible GUI elements are discussed herewith, the following discussion can apply to any appropriate haptic active GUI element. Accordingly, in the context of device **100**, processor **104** can direct display device **112** to display a number of haptic active GUI elements that taken together form representative GUI **600**. Such haptic active GUI elements can include, for example, first type haptic active button icon **602**, haptic active slider icon **604** having movable slider element **606**, keypad **608** formed of a number of second type haptic active buttons **610**. In the context of this discussion, the designations first and second type indicate that the haptic response associated with a particular GUI element. For example, a first type haptic response can be a high frequency vibration whereas a second type haptic response can palpable click. In should also be noted that button elements can be any appropriate shape or size.

[0075] FIG. **7** shows rectangular button element **702** and circular button element **704**. In the described embodiments, button elements **702** and **704** can be arranged to exhibit haptic response $H_{button}(x)$ that enables a user to accurately identify target areas **706** and/or **708**, respectively (also referred to as "sweet" spots). Target areas **706** and/or **708** can represent those portions of button elements **702** and **704** that are most sensitive to the application of pressure by a user and therefore