array **202** and to the touch surface connectors **208**, **210** to permit movement of the touch surface **104** under the influence of the drive electronics.

[0036] FIG. **6** illustrates a high-level block diagram of an example system, generally at **600**, that can be incorporated in the electronic device **100** (FIG. **1**) and utilized to implement the functionality described above and below. In the illustrated and described example, system **600** includes a microcontroller **602** which, in turn, includes a haptics customizing engine **604**, a computer-readable storage media in the form of an EEPROM **606**, an HID keyboard component **608**, a key scanning component **610**, and a haptics engine **612**. In addition, system **600** includes an adjustable DC/DC converter **614**, high side switches **616**, **618**, low side switches **620**, **622**, and an actuator **624**. An example of an actuator **624** is described above in the form of actuator array **202** (FIG. **2**).

[0037] In addition, a switch is illustrated generally at **630** and represents aspects of a touch surface that is configured to detect a user's engagement. Detection of a user's engagement can occur using any suitable type of sensor or detection apparatus. For example, in at least some embodiments, a capacitive-type sensor or a projected field-type sensor, surface acoustic wave, infrared display, optical/imaging resolution, and/or image sensing can be employed to sense a user's engagement. The operating principles of these types of sensors are generally known and, for the sake of brevity, are not described in detail here other than the explanation that appears just below.

[0038] In at least some embodiments, the detection apparatus establishes a sensory field that overlays a portion or all of touch surface **104** effective to define a sensor layer. The sensor layer can be considered as a region in which the presence and/or movement of a user, such as a user's finger, can be detected by the sensor layer. When the user's presence and/or movement is sensed by the sensor layer, an electrical signal can be sent to the drive electronics to effectively drive the electric-deformable material to cause the touch surface **104** to move in a desired fashion.

[0039] As shown, haptics customizing engine **604** is connected to the adjustable DC/DC converter **614** which, in turn, is connected to high side and low side switches **616**, **618** and **620**, **622** respectively. Actuator **624** is operably connected to the high side and low side switches as shown. The switches, both high side and low side are connected to haptics engine **612**.

[0040] In operation, in one or more embodiments, haptics customizing engine **604** is configured to load predefined haptic profiles from EEPROM **606** or modify parameters of existing profiles, either upon user/host request or by request from a self-adapting haptic hardware/software system. In addition, in one or more embodiments, haptics customizing engine **604** is configured to load new profiles to the haptics engine **612** or save new profiles to the EEPROM **606** as defined by a user or hardware/software developer. EEPROM **606** is configured to store haptic profile information for use in the haptic engine **612**. This information can be predefined at production time, as well as updated or supplemented at runtime by users, host system, developers, or an adaptive module of the haptic system.

[0041] HID keyboard components **608** is configured to provide Human Interface Device functionality to the host system (if necessary) in order to allow the haptic system to act in the same manner as a keypad, keyboard, touchpad, mouse, and also to provide haptic information to the host for display, modification, or other use.

[0042] Key scanning component **610** is configured to provide a mechanism for the haptic system to know when it should trigger playback of a haptic profile. The haptic system does not need to directly scan keys itself. Rather, the haptic system can alternatively take key/switch/input state information from another device, such as a keyboard controller, touch screen controller, or other user input device.

[0043] Haptics engine **612** is configured to control the input signals to the haptic actuator based on profile data supplied by the EEPROM **606**, haptics customization engine **604**, and/or whatever other sources of data exist.

[0044] The adjustable DC/DC converter is configured to supply the actuator operating voltage. The output voltage may or may not be regulated, may or may not be adjustable on the fly, or may or may not be adjustable at all. The DC/DC converter may or may not have any common or uncommon features of typical power supplies, such as over current protection, under voltage protection, sleep mode, off mode, voltage feedback, etc. On the fly adjustment allows the output voltage to be adjustable such that the host or haptics customization engine **604** can modify the output voltage.

[0045] In operation, in one or more embodiments, the high side and low side switches are configured to drive the voltage of an actuator phase to the actuator's maximum positive operating voltage, maximum negative operating voltage, or any voltage in between, including ground or a high impedance (floating) potential.

[0046] Having described an example electronic device, consider now a discussion of example circuitry that can be utilized to implement the embodiments described above.

Example Circuitry

[0047] FIG. **7** illustrates an example voltage regulator in accordance with one or more embodiments. In this example, the adjustable, low voltage regulator feeds a high voltage DC/DC converter, such as converter **614** in FIG. **6**, to allow a real-time adjustable high voltage level. In this example, a linear regulator with resistor-adjusted output voltage is used to drive a DC/DC converter whose output voltage is proportional to its input voltage. Additionally, the resistor path that controls the output voltage of the linear regulator contains an electrically-controlled potentiometer with a serial interface. This allows a microcontroller to serially set the resistance of the feedback branch and control the output of the linear regulator which in turn drives the DC/DC converter and controls the actuator drive voltage. It is to be appreciated there are many other ways to use regulated and unregulated supplies to provide the necessary operating voltage, and also that an adjustable high voltage rail is not necessary for every implementation, although if adjustability is required there are additionally many ways of providing adjustability.

[0048] FIG. **8** along with FIG. **10** illustrate a USB device that can allow real-time changes of haptic profiles and can act as an HID compliant keyboard. This circuit is an example implementation of one way to provide the system user with a means to interact with the haptic device. A USB device is provided which defines two interfaces. One is a standard HID keyboard, the other is a generic HID device functioning as a haptic customization engine. The standard keyboard interface allows the key presses on the haptic device to register on the host as keypresses of a keyboard. The haptic customization