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(54) **ACTIVE STYLUS WITH HIGH VOLTAGE**

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(51) **Int. Cl.**

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G06F 3/0354	(2013.01)
G06F 3/044	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/0383*** (2013.01); ***G06F 1/26*** (2013.01); ***G06F 3/03545*** (2013.01); ***G06F 3/044*** (2013.01); *G06F 2203/0384* (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.

See application file for complete search history.

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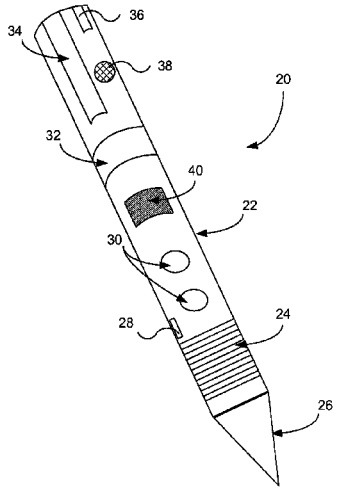
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(57) **ABSTRACT**

In certain embodiments, a stylus includes one or more electrodes and one or more computer-readable non-transitory storage media embodying logic for transmitting signals wirelessly to a device through a touch sensor of the device. At least some of the signals are high-voltage signals generated by a relatively large potential difference compared to a voltage within a voltage range of approximately 1 to approximately 3 volts. The stylus includes a stylus tip, and one or more of the one or more electrodes are disposed at the stylus tip.

20 Claims, 8 Drawing Sheets



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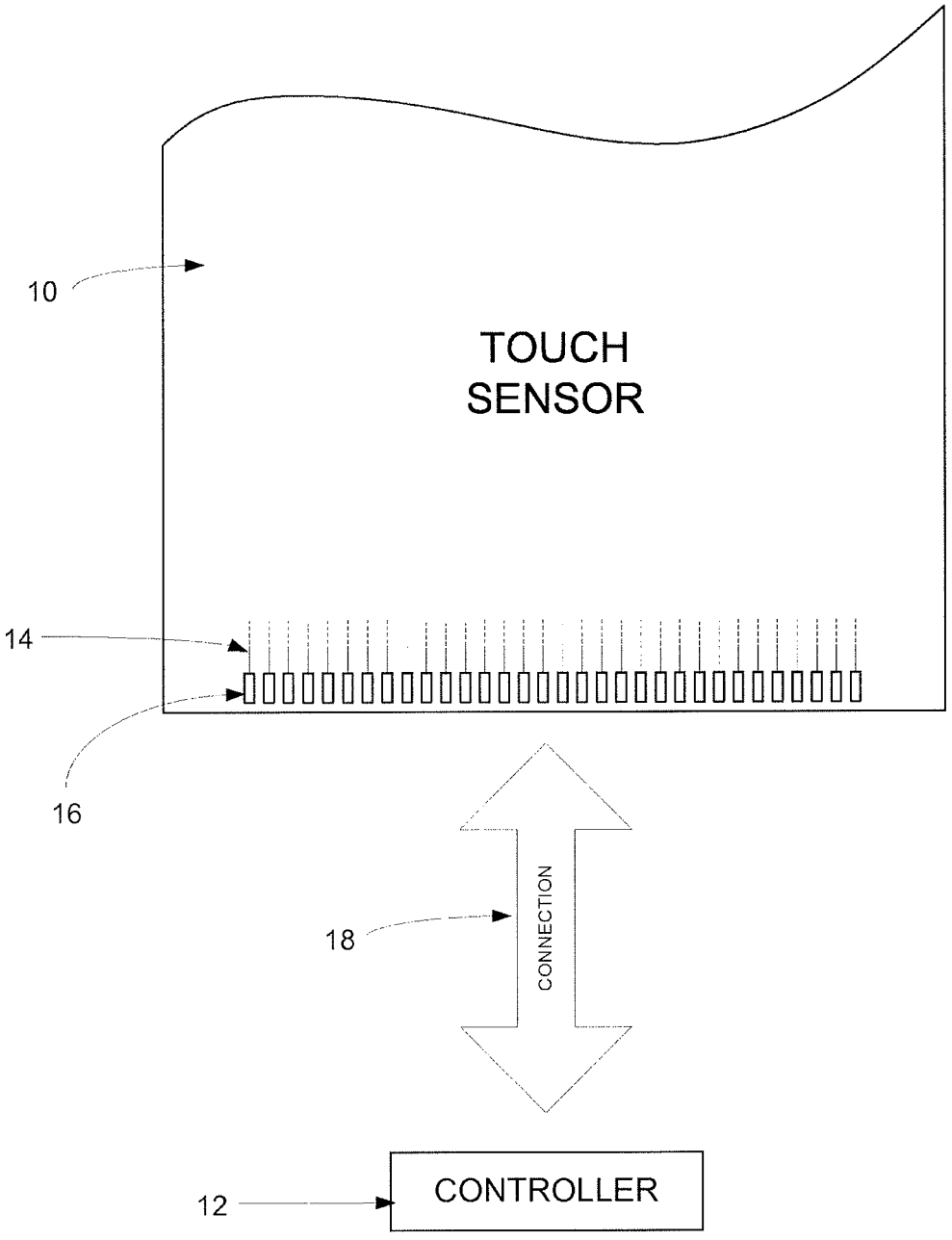


Figure 1

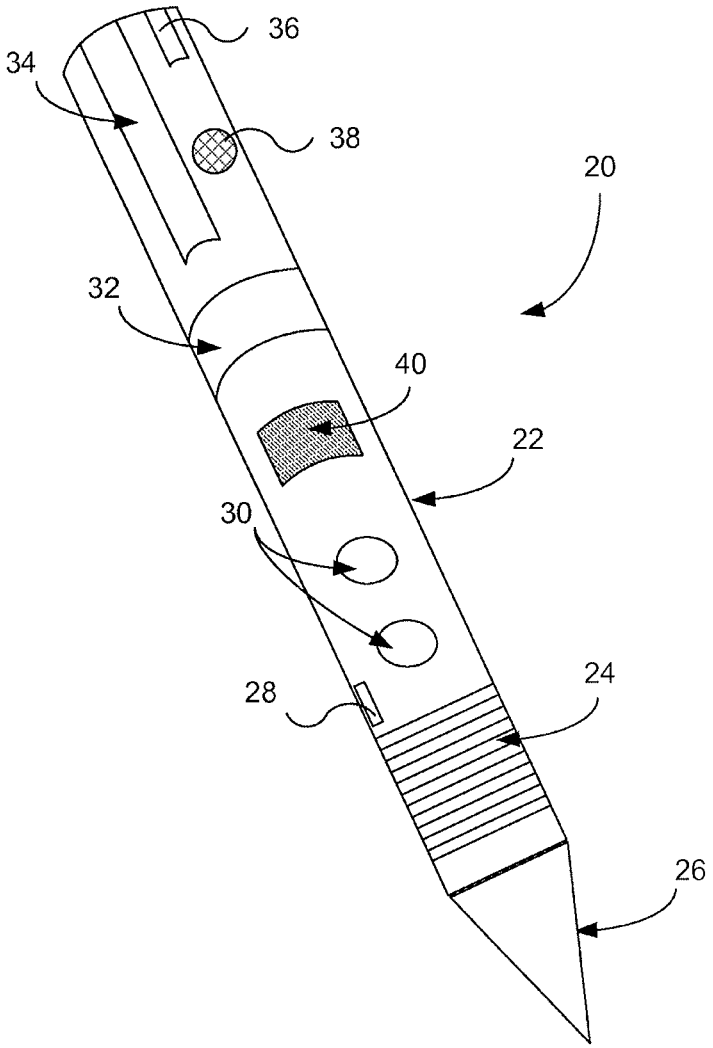


Figure 2

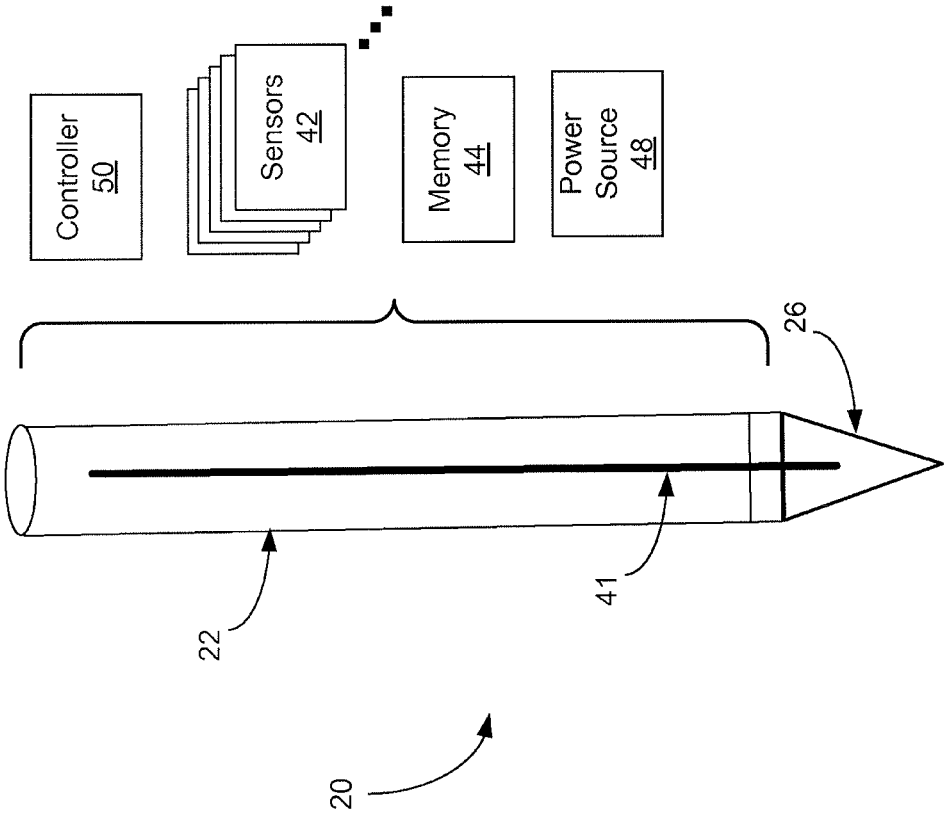

Controller
50
Sensors
42
Memory
44
Power
Source
48
26
22
41
20

Figure 3

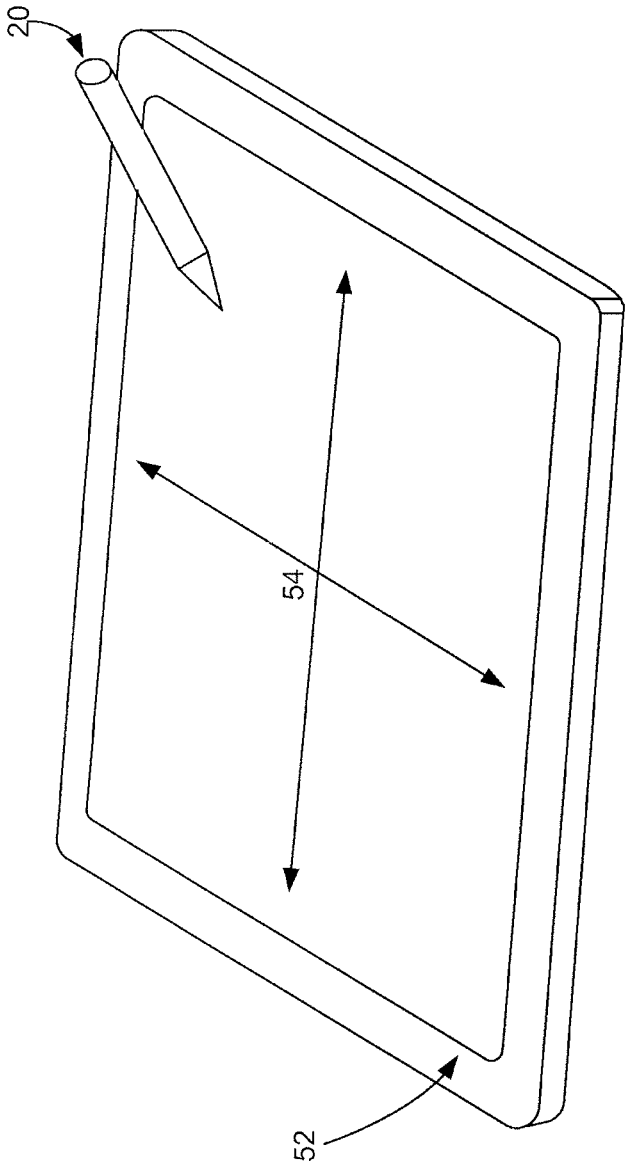


Figure 4

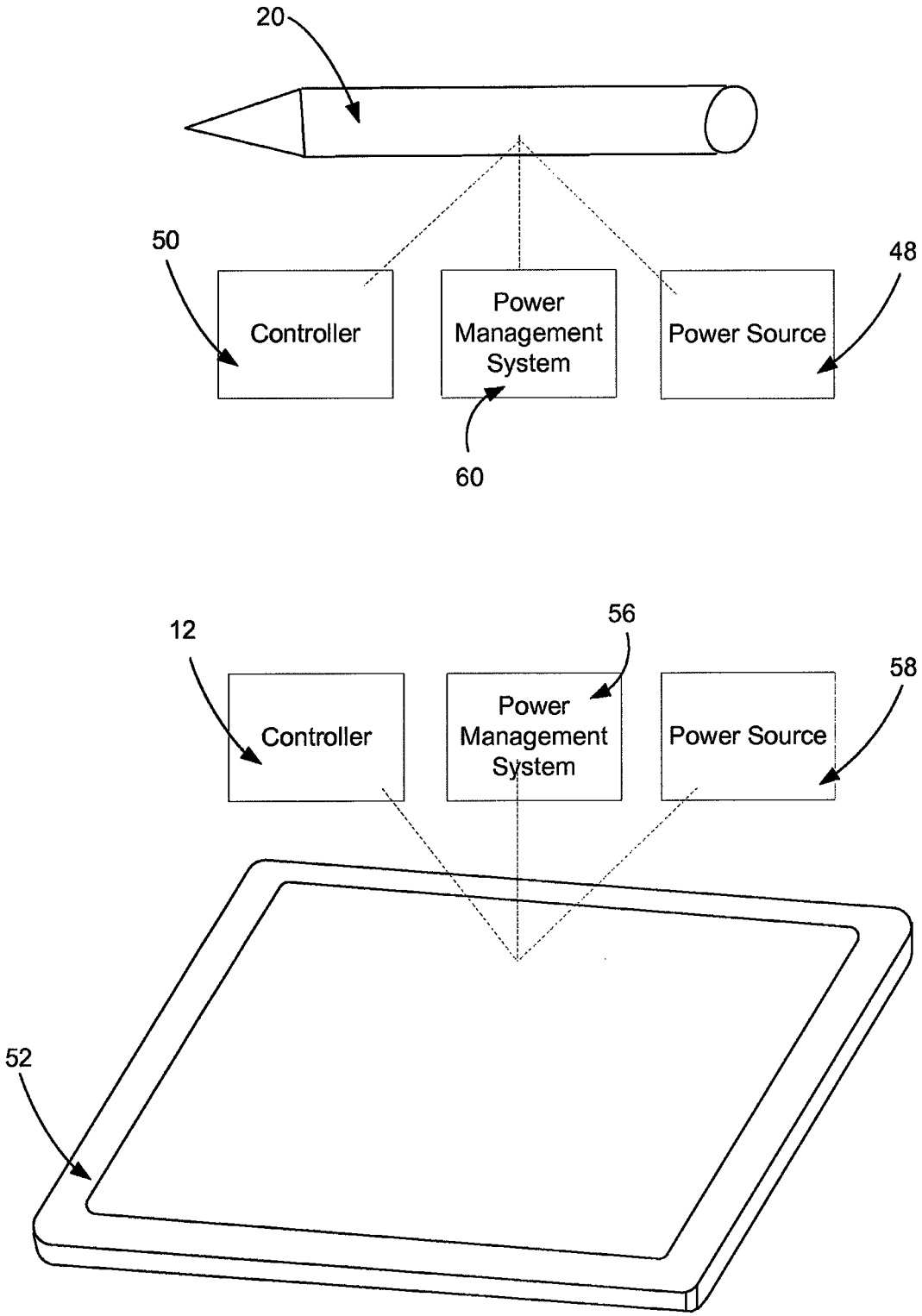

20
50
Controller
Power Management System
Power Source
48
60
12
56
58
Controller
Power Management System
Power Source
52

Figure 5

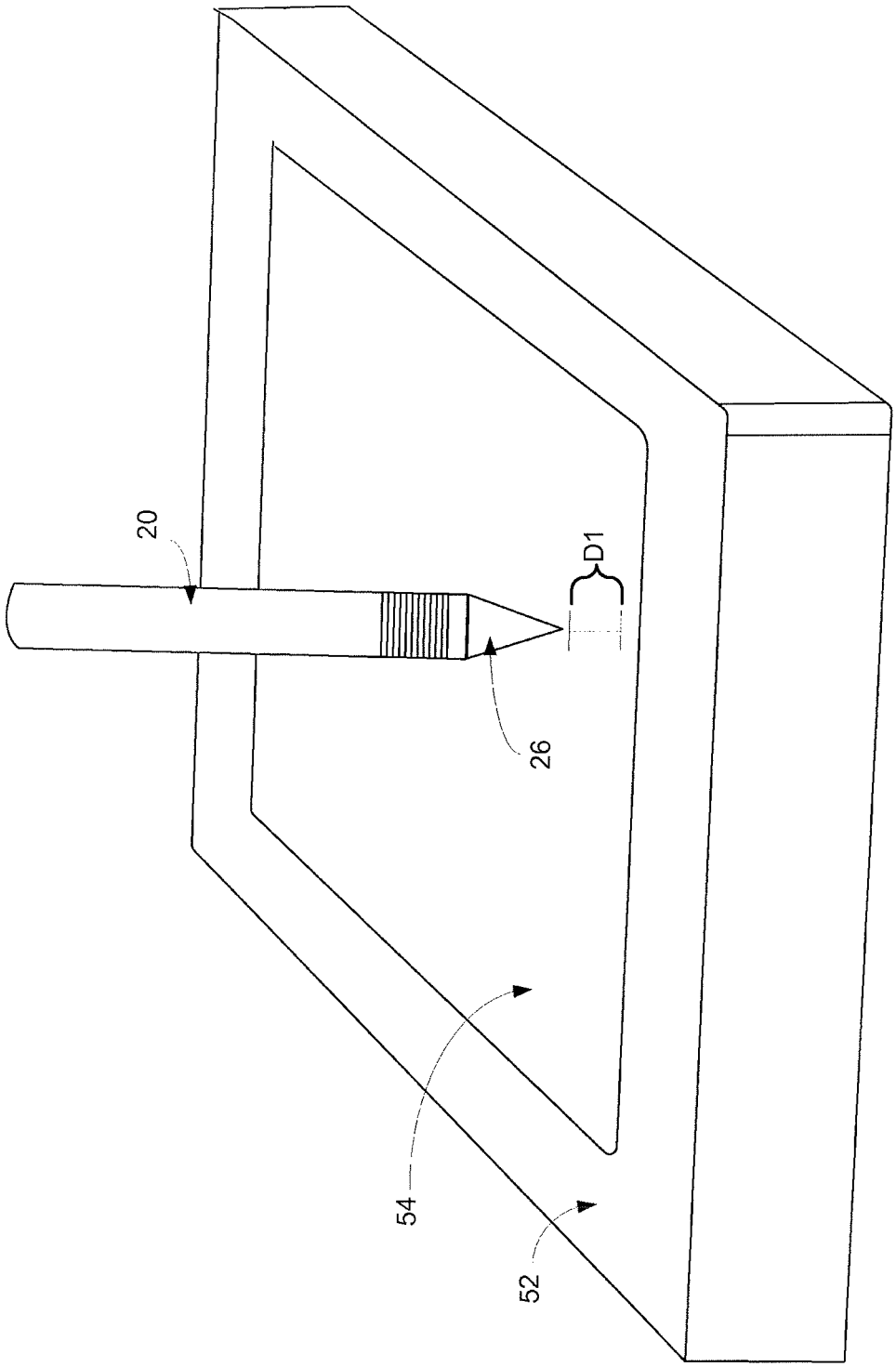


Figure 6A

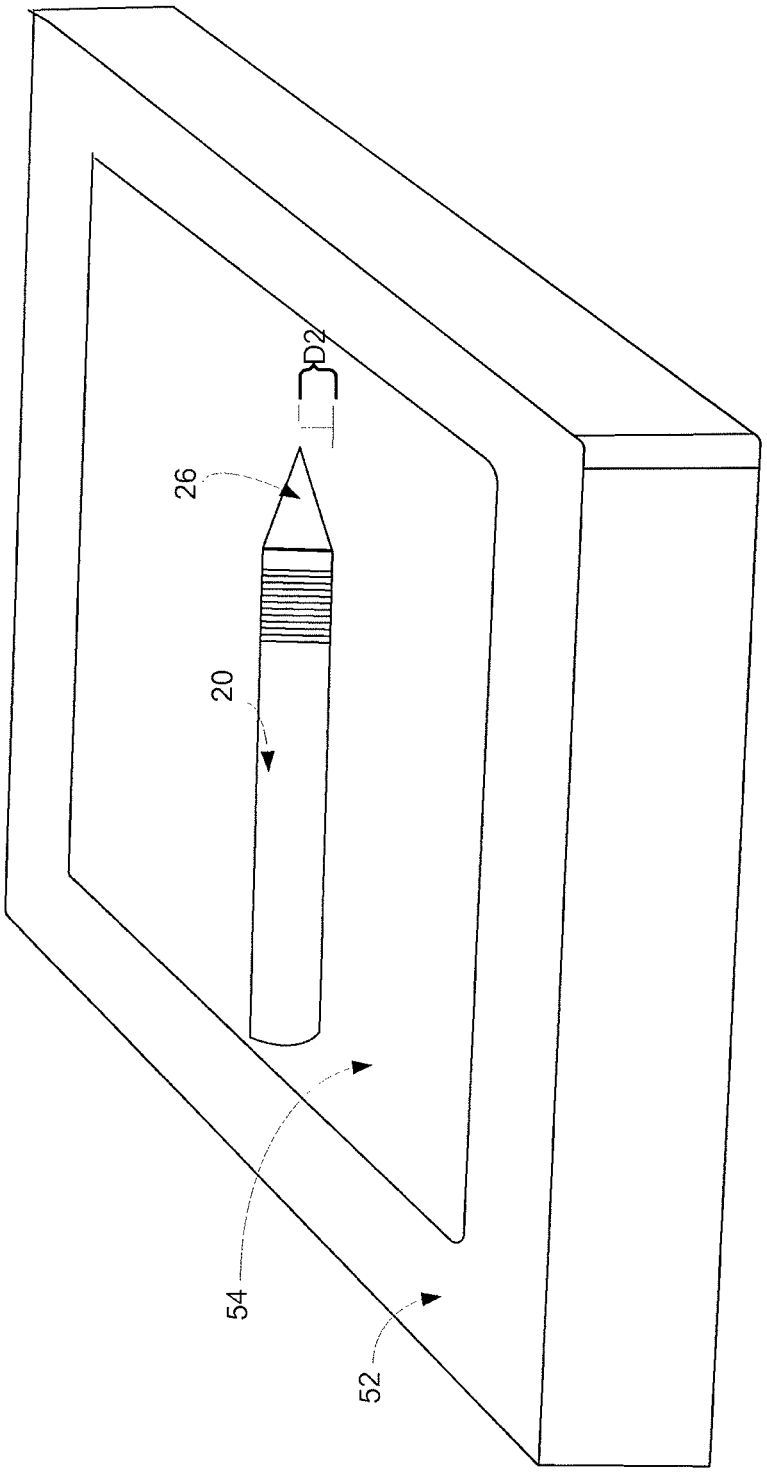


Figure 6B

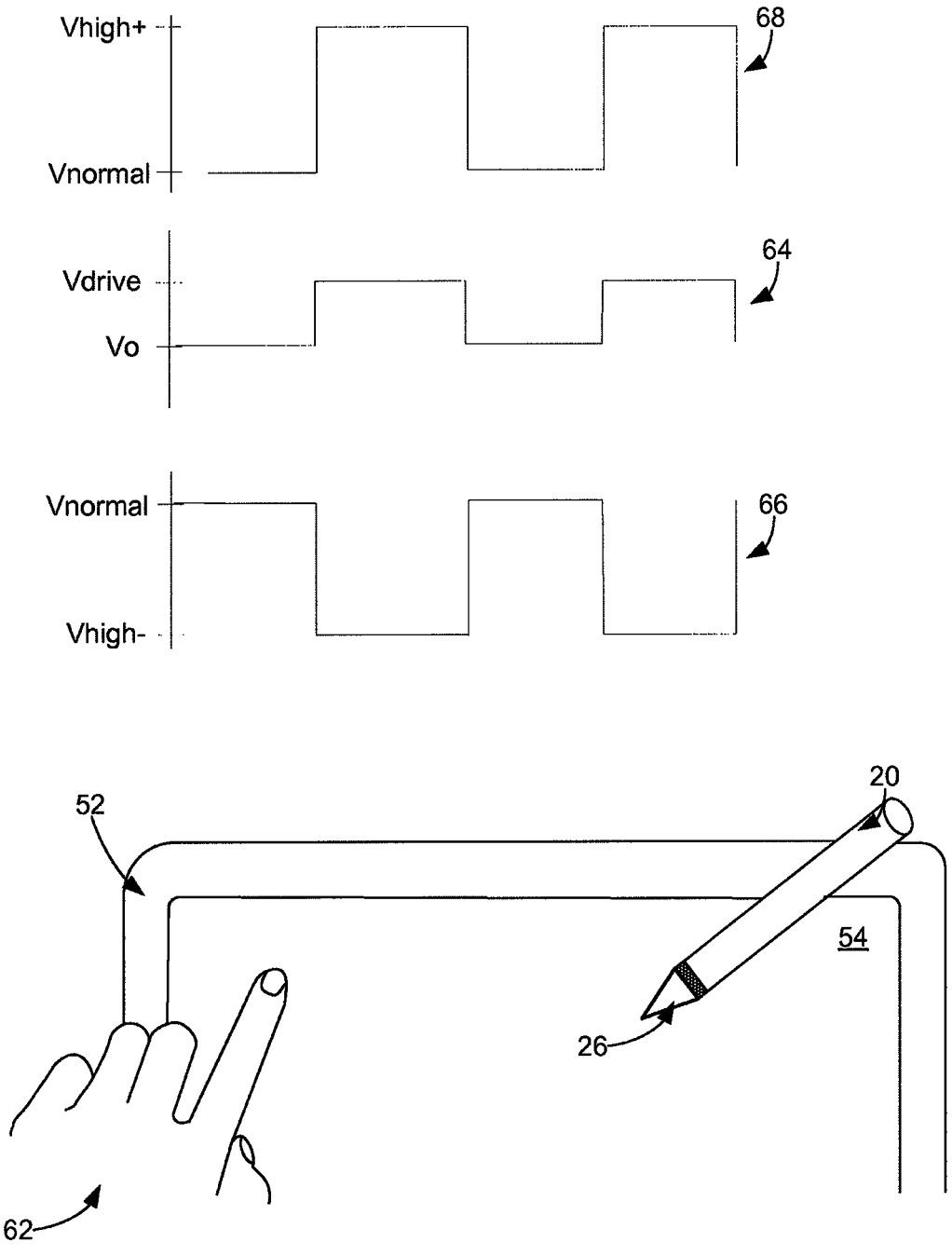


Figure 7

ACTIVE STYLUS WITH HIGH VOLTAGE

RELATED APPLICATIONS

This application is a continuation, under 35 U.S.C. § 120, of U.S. patent application Ser. No. 13/362,830, filed 31 Jan. 2012, which claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Ser. No. 61/553,114, filed 28 Oct. 2011, all of which are incorporated herein by reference.

TECHNICAL FIELD

This disclosure generally relates to active styluses.

BACKGROUND

A touch sensor may detect the presence and location of a touch or the proximity of an object (such as a user's finger or a stylus) within a touch-sensitive area of the touch sensor overlaid on a display screen, for example. In a touch-sensitive-display application, the touch sensor may enable a user to interact directly with what is displayed on the screen, rather than indirectly with a mouse or touch pad. A touch sensor may be attached to or provided as part of a desktop computer, laptop computer, tablet computer, personal digital assistant (PDA), smartphone, satellite navigation device, portable media player, portable game console, kiosk computer, point-of-sale device, or other suitable device. A control panel on a household or other appliance may include a touch sensor.

There are a number of different types of touch sensors, such as, for example, resistive touch screens, surface acoustic wave touch screens, and capacitive touch screens. Herein, reference to a touch sensor may encompass a touch screen, and vice versa, where appropriate. When an object touches or comes within proximity of the surface of the capacitive touch screen, a change in capacitance may occur within the touch screen at the location of the touch or proximity. A touch-sensor controller may process the change in capacitance to determine its position on the touch screen.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example touch sensor with an example touch-sensor controller.

FIG. **2** illustrates an example active stylus exterior.

FIG. **3** illustrates an example active stylus interior.

FIG. **4** illustrates an example active stylus with touch sensor device.

FIG. **5** illustrates example power management systems and power sources for a touch sensor system.

FIGS. **6**A and **6**B illustrate one or more electrodes in a tip of an active stylus, the electrodes transmitting high voltage signals that communicate the stylus's relative location or movement to a touch-sensitive device.

FIG. **7** illustrates an active stylus tip transmitting high-voltage signals that transmit information about the active stylus's contact with a touch-sensitive device to the touch-sensitive device.

DESCRIPTION OF EXAMPLE EMBODIMENTS

FIG. **1** illustrates an example touch sensor **10** with an example touch-sensor controller **12**. Touch sensor **10** and touch-sensor controller **12** may detect the presence and location of a touch or the proximity of an object within a touch-sensitive area of touch sensor **10**. Herein, reference to a touch sensor may encompass both the touch sensor and its touch-sensor controller, where appropriate. Similarly, reference to a touch-sensor controller may encompass both the touch-sensor controller and its touch sensor, where appropriate. Touch sensor **10** may include one or more touch-sensitive areas, where appropriate. Touch sensor **10** may include an array of drive and sense electrodes (or an array of electrodes of a single type) disposed on one or more substrates, which may be made of a dielectric material. Herein, reference to a touch sensor may encompass both the electrodes of the touch sensor and the substrate(s) that they are disposed on, where appropriate. Alternatively, where appropriate, reference to a touch sensor may encompass the electrodes of the touch sensor, but not the substrate(s) that they are disposed on.

An electrode (whether a ground electrode, guard electrode, drive electrode, or sense electrode) may be an area of conductive material forming a shape, such as for example a disc, square, rectangle, thin line, other suitable shape, or suitable combination of these. One or more cuts in one or more layers of conductive material may (at least in part) create the shape of an electrode, and the area of the shape may (at least in part) be bounded by those cuts. In particular embodiments, the conductive material of an electrode may occupy approximately 100% of the area of its shape. As an example and not by way of limitation, an electrode may be made of indium tin oxide (ITO) and the ITO of the electrode may occupy approximately 100% of the area of its shape (sometimes referred to as a 100% fill), where appropriate. In particular embodiments, the conductive material of an electrode may occupy substantially less than 100% of the area of its shape. As an example and not by way of limitation, an electrode may be made of fine lines of metal or other conductive material (FLM), such as for example copper, silver, or a copper- or silver-based material, and the fine lines of conductive material may occupy approximately 5% of the area of its shape in a hatched, mesh, or other suitable pattern. Herein, reference to FLM encompasses such material, where appropriate. Although this disclosure describes or illustrates particular electrodes made of particular conductive material forming particular shapes with particular fill percentages having particular patterns, this disclosure contemplates any suitable electrodes made of any suitable conductive material forming any suitable shapes with any suitable fill percentages having any suitable patterns.

Where appropriate, the shapes of the electrodes (or other elements) of a touch sensor may constitute in whole or in part one or more macro-features of the touch sensor. One or more characteristics of the implementation of those shapes (such as, for example, the conductive materials, fills, or patterns within the shapes) may constitute in whole or in part one or more micro-features of the touch sensor. One or more macro-features of a touch sensor may determine one or more characteristics of its functionality, and one or more micro-features of the touch sensor may determine one or more optical features of the touch sensor, such as transmittance, refraction, or reflection.

A mechanical stack may contain the substrate (or multiple substrates) and the conductive material forming the drive or sense electrodes of touch sensor **10**. As an example and not by way of limitation, the mechanical stack may include a first layer of optically clear adhesive (OCA) beneath a cover panel. The cover panel may be clear and made of a resilient material suitable for repeated touching, such as for example glass, polycarbonate, or poly(methyl methacrylate) (PMMA). This disclosure contemplates any suitable cover

panel made of any suitable material. The first layer of OCA may be disposed between the cover panel and the substrate with the conductive material forming the drive or sense electrodes. The mechanical stack may also include a second layer of OCA and a dielectric layer (which may be made of polyethylene terephthalate (PET) or another suitable material, similar to the substrate with the conductive material forming the drive or sense electrodes). As an alternative, where appropriate, a thin coating of a dielectric material may be applied instead of the second layer of OCA and the dielectric layer. The second layer of OCA may be disposed between the substrate with the conductive material making up the drive or sense electrodes and the dielectric layer, and the dielectric layer may be disposed between the second layer of OCA and an air gap to a display of a device including touch sensor **10** and touch-sensor controller **12**. As an example only and not by way of limitation, the cover panel may have a thickness of approximately 1 mm; the first layer of OCA may have a thickness of approximately 0.05 mm; the substrate with the conductive material forming the drive or sense electrodes may have a thickness of approximately 0.05 mm; the second layer of OCA may have a thickness of approximately 0.05 mm; and the dielectric layer may have a thickness of approximately 0.05 mm. Although this disclosure describes a particular mechanical stack with a particular number of particular layers made of particular materials and having particular thicknesses, this disclosure contemplates any suitable mechanical stack with any suitable number of any suitable layers made of any suitable materials and having any suitable thicknesses. As an example and not by way of limitation, in particular embodiments, a layer of adhesive or dielectric may replace the dielectric layer, second layer of OCA, and air gap described above, with there being no air gap to the display.

One or more portions of the substrate of touch sensor **10** may be made of polyethylene terephthalate (PET) or another suitable material. This disclosure contemplates any suitable substrate with any suitable portions made of any suitable material. In particular embodiments, the drive or sense electrodes in touch sensor **10** may be made of ITO in whole or in part. In particular embodiments, the drive or sense electrodes in touch sensor **10** may be made of fine lines of metal or other conductive material. As an example and not by way of limitation, one or more portions of the conductive material may be copper or copper-based and have a thickness of approximately 5 μm or less and a width of approximately 10 μm or less. As another example, one or more portions of the conductive material may be silver or silver-based and similarly have a thickness of approximately 5 un or less and a width of approximately 10 μm or less. This disclosure contemplates any suitable electrodes made of any suitable material.

Touch sensor **10** may implement a capacitive form of touch sensing. In a mutual-capacitance implementation, touch sensor **10** may include an array of drive and sense electrodes forming an array of capacitive nodes. A drive electrode and a sense electrode may form a capacitive node. The drive and sense electrodes forming the capacitive node may come near each other, but not make electrical contact with each other. Instead, the drive and sense electrodes may be capacitively coupled to each other across a space between them. A pulsed or alternating voltage applied to the drive electrode (by touch-sensor controller **12**) may induce a charge on the sense electrode, and the amount of charge induced may be susceptible to external influence (such as a touch or the proximity of an object). When an object touches or comes within proximity of the capacitive node, a change in capacitance may occur at the capacitive node and touch-sensor controller **12** may measure the change in capacitance. By measuring changes in capacitance throughout the array, touch-sensor controller **12** may determine the position of the touch or proximity within the touch-sensitive area(s) of touch sensor **10**.

In a self-capacitance implementation, touch sensor **10** may include an array of electrodes of a single type that may each form a capacitive node. When an object touches or comes within proximity of the capacitive node, a change in self-capacitance may occur at the capacitive node and controller **12** may measure the change in capacitance, for example, as a change in the amount of charge needed to raise the voltage at the capacitive node by a pre-determined amount. As with a mutual-capacitance implementation, by measuring changes in capacitance throughout the array, controller **12** may determine the position of the touch or proximity within the touch-sensitive area(s) of touch sensor **10**. This disclosure contemplates any suitable form of capacitive touch sensing, where appropriate.

In particular embodiments, one or more drive electrodes may together form a drive line running horizontally or vertically or in any suitable orientation. Similarly, one or more sense electrodes may together form a sense line running horizontally or vertically or in any suitable orientation. In particular embodiments, drive lines may run substantially perpendicular to sense lines. Herein, reference to a drive line may encompass one or more drive electrodes making up the drive line, and vice versa, where appropriate. Similarly, reference to a sense line may encompass one or more sense electrodes making up the sense line, and vice versa, where appropriate.

Touch sensor **10** may have drive and sense electrodes disposed in a pattern on one side of a single substrate. In such a configuration, a pair of drive and sense electrodes capacitively coupled to each other across a space between them may form a capacitive node. For a self-capacitance implementation, electrodes of only a single type may be disposed in a pattern on a single substrate. In addition or as an alternative to having drive and sense electrodes disposed in a pattern on one side of a single substrate, touch sensor **10** may have drive electrodes disposed in a pattern on one side of a substrate and sense electrodes disposed in a pattern on another side of the substrate. Moreover, touch sensor **10** may have drive electrodes disposed in a pattern on one side of one substrate and sense electrodes disposed in a pattern on one side of another substrate. In such configurations, an intersection of a drive electrode and a sense electrode may form a capacitive node. Such an intersection may be a location where the drive electrode and the sense electrode "cross" or come nearest each other in their respective planes. The drive and sense electrodes do not make electrical contact with each other instead they are capacitively coupled to each other across a dielectric at the intersection. Although this disclosure describes particular configurations of particular electrodes forming particular nodes, this disclosure contemplates any suitable configuration of any suitable electrodes forming any suitable nodes. Moreover, this disclosure contemplates any suitable electrodes disposed on any suitable number of any suitable substrates in any suitable patterns.

As described above, a change in capacitance at a capacitive node of touch sensor **10** may indicate a touch or proximity input at the position of the capacitive node. Touch-sensor controller **12** may detect and process the change in capacitance to determine the presence and location of the touch or proximity input. Touch-sensor controller

12 may then communicate information about the touch or proximity input to one or more other components (such one or more central processing units (CPUs)) of a device that includes touch sensor 10 and touch-sensor controller 12, which may respond to the touch or proximity input by initiating a function of the device (or an application running on the device). Although this disclosure describes a particular touch-sensor controller having particular functionality with respect to a particular device and a particular touch sensor, this disclosure contemplates any suitable touch-sensor controller having any suitable functionality with respect to any suitable device and any suitable touch sensor.

Touch-sensor controller 12 may be one or more integrated circuits (ICs), such as for example general-purpose microprocessors, microcontrollers, programmable logic devices (PLDs) or programmable logic arrays (PLAs), fuse-programmable arrays (FPGAs), or application-specific ICs (ASICs). In particular embodiments, touch-sensor controller 12 comprises analog circuitry, digital logic, and digital non-volatile memory. In particular embodiments, touch-sensor controller 12 is disposed on a flexible printed circuit (FPC) bonded to the substrate of touch sensor 10, as described below. The FPC may be active or passive, where appropriate. In particular embodiments multiple touch-sensor controllers 12 are disposed on the FPC. Touch-sensor controller 12 may include a processor unit, a drive unit, a sense unit, and a storage unit. The drive unit may supply drive signals to the drive electrodes of touch sensor 10. The sense unit may sense charge at the capacitive nodes of touch sensor 10 and provide measurement signals to the processor unit representing capacitances at the capacitive nodes. The processor unit may control the supply and timing of drive signals to the drive electrodes by the drive unit and process measurement signals from the sense unit to detect and process the presence and location of a touch or proximity input within the touch-sensitive area(s) of touch sensor 10. The processor unit may also track changes in the position of a touch or proximity input within the touch-sensitive area(s) of touch sensor 10. The storage unit may store programming for execution by the processor unit, including programming for controlling the drive unit to supply drive signals to the drive electrodes, programming for processing measurement signals from the sense unit, and other suitable programming, where appropriate. Although this disclosure describes a particular touch-sensor controller having a particular implementation with particular components, this disclosure contemplates any suitable touch-sensor controller having any suitable implementation with any suitable components.

Tracks 14 of conductive material disposed on the substrate of touch sensor 10 may couple the drive or sense electrodes of touch sensor 10 to connection pads 16, also disposed on the substrate of touch sensor 10. As described below, connection pads 16 facilitate coupling of tracks 14 to touch-sensor controller 12. Tracks 14 may extend into or around (e.g. at the edges of) the touch-sensitive areas) of touch sensor 10. Particular tracks 14 may provide drive connections for coupling touch-sensor controller 12 to drive electrodes of touch sensor 10, through which the drive unit of touch-sensor controller 12 may supply drive signals to the drive electrodes. Other tracks 14 may provide sense connections for coupling touch-sensor controller 12 to sense electrodes of touch sensor 10, through which the sense unit of touch-sensor controller 12 may sense charge at the capacitive nodes of touch sensor 10. Tracks 14 may be made of fine lines of metal or other conductive material. As an example and not by way of limitation, the conductive material of tracks 14 may be copper or copper-based and have a width of approximately 100 μm or less. As another example, the conductive material of tracks 14 may be silver or silver-based and have a width of approximately 100 μm or less. In particular embodiments, tracks 14 may be made of ITO in whole or in part in addition or as an alternative to fine lines of metal or other conductive material. Although this disclosure describes particular tracks made of particular materials with particular widths, this disclosure contemplates any suitable tracks made of any suitable materials with any suitable widths. In addition to tracks 14, touch sensor 10 may include one or more ground lines terminating at a ground connector (which may be a connection pad 16) at an edge of the substrate of touch sensor 10 (similar to tracks 14).

Connection pads 16 may be located along one or more edges of the substrate, outside the touch-sensitive area(s) of touch sensor 10. As described above, touch-sensor controller 12 may be on an FPC. Connection pads 16 may be made of the same material as tracks 14 and may be bonded to the FPC using an anisotropic conductive film (ACF). Connection 18 may include conductive lines on the FPC coupling touch-sensor controller 12 to connection pads 16, in turn coupling touch-sensor controller 12 to tracks 14 and to the drive or sense electrodes of touch sensor 10. In another embodiment, connection pads 16 may be connected to an electro-mechanical connector (such as a zero insertion force wire-to-board connector); in this embodiment, connection 18 may not need to include an FPC. This disclosure contemplates any suitable connection 18 between touch-sensor controller 12 and touch sensor 10.

FIG. 2 illustrates an example exterior of an example active stylus 20. Active stylus 20 may include one or more components, such as buttons 30 or sliders 32 and 34 integrated with an outer body 22. These external components may provide for interaction between active stylus 20 and a user or between a device and a user. As an example and not by way of limitation, interactions may include communication between active stylus 20 and a device, enabling or altering functionality of active stylus 20 or a device, or providing feedback to or accepting input from one or more users. The device may by any suitable device, such as, for example and without limitation, a desktop computer, laptop computer, tablet computer, personal digital assistant (PDA), smartphone, satellite navigation device, portable media player, portable game console, kiosk computer, point-of-sale device, or other suitable device. Although this disclosure provides specific examples of particular components configured to provide particular interactions, this disclosure contemplates any suitable component configured to provide any suitable interaction. Active stylus 20 may have any suitable dimensions with outer body 22 made of any suitable material or combination of materials, such as, for example and without limitation, plastic or metal. In particular embodiments, exterior components (e.g. 30 or 32) of active stylus 20 may interact with internal components or programming of active stylus 20 or may initiate one or more interactions with one or more devices or other active styluses 20.

As described above, actuating one or more particular components may initiate an interaction between active stylus 20 and a user or between the device and the user. Components of active stylus 20 may include one or more buttons 30 or one or more sliders 32 and 34. As an example and not by way of limitation, buttons 30 or sliders 32 and 34 may be mechanical or capacitive and may function as a roller, trackball, or wheel. As another example, one or more sliders 32 or 34 may function as a vertical slider 34 aligned along

a longitudinal axis, while one or more wheel sliders **32** may be aligned along the circumference of active stylus **20**. In particular embodiments, capacitive sliders **32** and **34** or buttons **30** may be implemented using one or more touch-sensitive areas. Touch-sensitive areas may have any suitable shape, dimensions, location, or be made from any suitable material. As an example and not by way of limitation, sliders **32** and **34** or buttons **30** may be implemented using areas of flexible mesh formed using lines of conductive material. As another example, sliders **32** and **34** or buttons **30** may be implemented using a FPC.

Active stylus **20** may have one or more components configured to provide feedback to or accepting feedback from a user, such as, for example and without limitation, tactile, visual, or audio feedback. Active stylus **20** may include one or more ridges or grooves **24** on its outer body **22**. Ridges or grooves **24** may have any suitable dimensions, have any suitable spacing between ridges or grooves, or be located at any suitable area on outer body **22** of active stylus **20**. As an example and not by way of limitation, ridges **24** may enhance a user's grip on outer body **22** of active stylus **20** or provide tactile feedback to or accept tactile input from a user. Active stylus **20** may include one or more audio components **38** capable of transmitting and receiving audio signals. As an example and not by way of limitation, audio component **38** may contain a microphone capable of recording or transmitting one or more users' voices. As another example, audio component **38** may provide an auditory indication of a power status of active stylus **20**. Active stylus **20** may include one or more visual feedback components **36**, such as a light-emitting diode (LED) indicator. As an example and not by way of limitation, visual feedback component **36** may indicate a power status of active stylus **20** to the user.

One or more modified surface areas **40** may form one or more components on outer body **22** of active stylus **20**. Properties of modified surface areas **40** may be different than properties of the remaining surface of outer body **22**. As an example and not by way of limitation, modified surface area **40** may be modified to have a different texture, temperature, or electromagnetic characteristic relative to the surface properties of the remainder of outer body **22**. Modified surface area **40** may be capable of dynamically altering its properties, for example by using haptic interfaces or rendering techniques. A user may interact with modified surface area **40** to provide any suitable functionally. For example and not by way of limitation, dragging a finger across modified surface area **40** may initiate an interaction, such as data transfer, between active stylus **20** and a device.

One or more components of active stylus **20** may be configured to communicate data between active stylus **20** and the device. For example, active stylus **20** may include one or more tips **26** or nibs. Tip **26** may include one or more electrodes configured to communicate data between active stylus **20** and one or more devices or other active styluses. Tip **26** may be made of any suitable material, such as a conductive material, and have any suitable dimensions, such as, for example, a diameter of 1 mm or less at its terminal end. Active stylus **20** may include one or more ports **28** located at any suitable location on outer body **22** of active stylus **20**. Port **28** may be configured to transfer signals or information between active stylus **20** and one or more devices or power sources. Port **28** may transfer signals or information by any suitable technology, such as, for example, by universal serial bus (USB) or Ethernet connections. Port **28** may transmit or receive signals wirelessly, for example using BlueTooth or wireless fidelity (WiFi) technologies. Although this disclosure describes and illustrates a particular configuration of particular components with particular locations, dimensions, composition and functionality, this disclosure contemplates any suitable configuration of suitable components with any suitable locations, dimensions, composition, and functionality with respect to active stylus **20**.

FIG. **3** illustrates an example internal components of example active stylus **20**. Active stylus **20** may include one or more internal components, such as a controller **50**, sensors **42**, memory **44**, or power source **48**. In particular embodiments, one or more internal components may be configured to provide for interaction between active stylus **20** and a user or between a device and a user. In other particular embodiments, one or more internal components, in conjunction with one or more external components described above, may be configured to provide interaction between active stylus **20** and a user or between a device and a user. As an example and not by way of limitation, interactions may include communication between active stylus **20** and a device, enabling or altering functionality of active stylus **20** or a device, or providing feedback to or accepting input from one or more users.

Controller **50** may be a microcontroller or any other type of processor suitable for controlling the operation of active stylus **20**. Controller **50** may be one or more ICs—such as, for example, general-purpose microprocessors, microcontrollers, PLDs, PLAs, or ASICs. Controller **50** may include a processor unit, a drive unit, a sense unit, and a storage unit. The drive unit may supply signals to electrodes of tip **26** through center shaft **41**. The drive unit may also supply signals to control or drive sensors **42** or one or more external components of active stylus **20**. The sense unit may sense signals received by electrodes of tip **26** through center shaft **41** and provide measurement signals to the processor unit representing input from a device. The sense unit may also sense signals generated by sensors **42** or one or more external components and provide measurement signals to the processor unit representing input from a user. The processor unit may control the supply and timing of signals to the electrodes of tip **26** and process measurement signals from the sense unit to detect and process input from the device. The processor unit may also process measurement signals from sensors **42** or one or more external components. The storage unit may store programming for execution by the processor unit, including programming for controlling the drive unit to supply signals to the electrodes of tip **26**, programming for processing measurement signals from the sense unit corresponding to input from the device, programming for processing measurement signals from sensors **42** or external components to initiate a pre-determined function or gesture to be performed by active stylus **20** or the device, and other suitable programming, where appropriate. As an example and not by way of limitation, programming executed by controller **50** may electronically filter signals received from the sense unit. Although this disclosure describes a particular controller **50** having a particular implementation with particular components, this disclosure contemplates any suitable controller having any suitable implementation with any suitable components.

In particular embodiments, active stylus **20** may include one or more sensors **42**, such as touch sensors, gyroscopes, accelerometers, contact sensors, or any other type of sensor that detect or measure data about the environment in which active stylus **20** operates. Sensors **42** may detect and measure one or more characteristic of active stylus **20**, such as acceleration or movement, orientation, contact, pressure on

outer body **22**, force on tip **26**, vibration, or any other suitable characteristic of active stylus **20**. As an example and not by way of limitation, sensors **42** may be implemented mechanically, electronically, or capcitively. As described above, data detected or measured by sensors **42** communicated to controller **50** may initiate a pre-determined function or gesture to be performed by active stylus **20** or the device. In particular embodiments, data detected or received by sensors **42** may be stored in memory **44**. Memory **44** may be any form of memory suitable for storing data in active stylus **20**. In other particular embodiments, controller **50** may access data stored in memory **44**. As an example and not by way of limitation, memory **44** may store programming for execution by the processor unit of controller **50**. As another example, data measured by sensors **42** may be processed by controller **50** and stored in memory **44**.

Power source **48** may be any type of stored-energy source, including electrical or chemical-energy sources, suitable for powering the operation of active stylus **20**. In particular embodiments, power source **48** may be charged by energy from a user or device. As an example and not by way of limitation, power source **48** may be a rechargeable battery that may be charged by motion induced on active stylus **20**. In other particular embodiments, power source **48** of active stylus **20** may provide power to or receive power from the device. As an example and not by way of limitation, power may be inductively transferred between power source **48** and a power source of the device.

FIG. **4** illustrates an example active stylus **20** with an example device **52**. Device **52** may have a display (not shown) and a touch sensor with a touch-sensitive area **54**. Device **52** display may be a liquid crystal display (LCD), a LED display, a LED-backlight LCD, or other suitable display and may be visible though a cover panel and substrate (and the drive and sense electrodes of the touch sensor disposed on it) of device **52**. Although this disclosure describes a particular device display and particular display types, this disclosure contemplates any suitable device display and any suitable display types.

Device **52** electronics may provide the functionality of device **52**. As example and not by way of limitation, device **52** electronics may include circuitry or other electronics for wireless communication to or from device **52**, execute programming on device **52**, generating graphical or other user interfaces (UIs) for device **52** display to display to a user, managing power to device **52** from a battery or other power source, taking still pictures, recording video, other suitable functionality, or any suitable combination of these. Although this disclosure describes particular device electronics providing particular functionality of a particular device, this disclosure contemplates any suitable device electronics providing any suitable functionality of any suitable device.

In particular embodiments, active stylus **20** and device **52** may be synchronized prior to communication of data between active stylus **20** and device **52**. As an example and not by way of limitation, active stylus **20** may be synchronized to device through a pre-determined bit sequence transmitted by the touch sensor of device **52**. As another example, active stylus **20** may be synchronized to device by processing the drive signal transmitted by drive electrodes of the touch sensor of device **52**. Active stylus **20** may interact or communicate with device **52** when active stylus **20** is brought in contact with or in proximity to touch-sensitive area **54** of the touch sensor of device **52**. In particular embodiments, interaction between active stylus **20** and device **52** may be capacitive or inductive. As an example and not by way of limitation, when active stylus **20** is brought in contact with or in the proximity of touch-sensitive area **54** of device **52**, signals generated by active stylus **20** may influence capacitive nodes of touch-sensitive area of device **52** or vice versa. As another example, a power source of active stylus **20** may be inductively charged through the touch sensor of device **52**, or vice versa. Although this disclosure describes particular interactions and communications between active stylus **20** and device **52**, this disclosure contemplates any suitable interactions and communications through any suitable means, such as mechanical forces, current, voltage, or electromagnetic fields.

In particular embodiments, measurement signal from the sensors of active stylus **20** may initiate, provide for, or terminate interactions between active stylus **20** and one or more devices **52** or one or more users, as described above. Interaction between active stylus **20** and device **52** may occur when active stylus **20** is contacting or in proximity to device **52**. As an example and not by way of limitation, a user may perform a gesture or sequence of gestures, such as shaking or inverting active stylus **20**, whilst active stylus **20** is hovering above touch-sensitive area **54** of device **52**. Active stylus may interact with device **52** based on the gesture performed with active stylus **20** to initiate a pre-determined function, such as authenticating a user associated with active stylus **20** or device **52**. Although this disclosure describes particular movements providing particular types of interactions between active stylus **20** and device **52**, this disclosure contemplates any suitable movement influencing any suitable interaction in any suitable way.

FIG. **5** illustrates example power management systems and power sources for a touch sensor system. Power management systems and power sources may be associated with components of the touch sensor system, such as active styluses, touch-sensitive devices, and the components associated with the active styluses and touch-sensitive devices. Active stylus **20** may have one or more power sources **48**. Likewise, touch-sensitive device **52** may have one or more power sources **58**. Power sources **48** and **58** may communicate with controllers **50** and **12**, respectively. In particular embodiments, the communication is controlled or monitored by one or more graphical user interfaces operating on any suitable active stylus or device. Power sources **48** and **58** may store, receive, transmit, or produce electric energy suitable for use by a touch sensor system or associated components. In particular embodiments, electric energy is received or transmitted by any suitable method such as wiring, direct physical contact, temperature gradients, piezoelectric materials, mechanical methods, electromagnetic radiation, or any suitable combination thereof. Power sources **48** and **58** may include any suitable component that delivers, receives, produces, or modifies electric energy, such as a transformer. Power sources **48** and **58** may convert any kind of electric energy stored, produced, received, or transmitted to any other kind of electric energy suitable for use by a touch sensor system and its associated components. Herein, electric energy may take any suitable form, such as an electric field, a magnetic field, a static configuration of electric charge, and electric current.

Power source **48** may be external or internal to active stylus **20**, and power source **58** may be external or internal to touch-sensitive device **52**. In particular embodiments, an internal power source is a battery or a capacitor. In particular embodiments, an external power source is a wall outlet or another device, such as a computer. A power source internal to one active stylus or device may be external to another

active stylus or device. As an example of a particular embodiment, power source **58** is internal to touch-sensitive device **52**, while also serving as an external power source **48** for active stylus **20**. While this disclosure describes specific examples of particular embodiments of power sources **48** and **58**, this disclosure contemplates any suitable power sources **48** and **58** delivering, receiving, storing or producing any suitable kind of electric energy by any suitable method to or from any suitable sources or destinations.

Active stylus **20** may have one or more power management systems **60**. Likewise, touch-sensitive device **52** may have one or more power management systems **56**. Power management systems **60** and **56** may communicate with controllers **50** and **12**, respectively. In particular embodiments, the communication is controlled or monitored by a graphical user interface operating on an active stylus or device. Power management systems **60** and **56** may control, modify, or record the receipt, production, or transfer of electric energy suitable for use by a touch sensor system or its associated components. In particular embodiments, power management systems **60** and **56** allocate to one or more components associated with a touch sensor system electric energy existing on or incoming to one or more components associated with the touch sensor system. In particular embodiments, power management systems **60** and **56** use criteria, such as metrics, to initiate, allocate, and terminate the allocation of energy between one or more components of a touch sensor system. In particular embodiments, power management systems **60** and **56** allocate a particular amount of power to one or more components associated with a touch sensor system, and are capable of allocating different amounts of power to particular components at different times. As an example, a power management system **60** determines power modes of an active stylus. A power mode describes the amount of power sent to one or more components associated with an active stylus. The power management system **60** may transition the active stylus between power modes based at least in part on input from a user or an active stylus or device. A graphical user interface may allow a user to control or monitor the power modes of an active stylus and the method or criteria used to transition between them.

In particular embodiments, an active stylus may have one or more components, such as a transformer or charge pump, capable of producing substantially high voltage. Herein, high voltage indicates a relatively large potential difference compared to voltages used by an active stylus in normal operation, whether the relatively large potential difference is positive or negative. As an example, an active stylus produces voltage of approximately 1-3 volts while in normal operation. An electrical circuit of the active stylus contains a transformer capable of converting ordinary-operation voltage to high voltage in the range of 10-20 volts, for example approximately 12 volts. In particular embodiments, the high voltage produced by an active stylus is used to power components of the active stylus, such as one or more electrodes. As an example, a tip of an active stylus may have a substrate on which one or more electrodes are placed. High voltage may be delivered to the one or more electrodes. The one or more electrodes may transmit high-voltage signals to a device, such as a touch-sensitive device. As an example, FIGS. **6**A and **6**B illustrate one or more electrodes in tip **26** of active stylus **20** transmitting high voltage signals that communicate the stylus's relative location or movement to touch-sensitive device **52**.

In FIG. **6**A, active stylus **20** is near touch-sensitive display **54** of touch-sensitive device **52**. Tip **26** of active stylus **20** is located a distance D**1** away from touch-sensitive display **54**. As an example, D**1** may be between approximately 0 and 25 millimeters. One or more electrodes in tip **26** receive high voltage from active stylus **20** and output high-voltage signals to touch-sensitive device **52**. Conductive material, such as drive and sense lines near touch-sensitive display **54**, and associated electronics in touch-sensitive device **52** sense the high-voltage signals. As an example, high-voltage signals produced by electrodes in tip **26** alter the net charge present on sense lines in the proximity of tip **26**, communicating information about the location of active stylus **20** in directions parallel to touch-sensitive display **52**. The net charge present on sense lines also depends on the distance D**1** tip **26** is from touch-sensitive display **54**, communicating information to touch-sensitive device **52** about the location of active stylus **20** in directions perpendicular to touch-sensitive display **54**. In particular embodiments, motion of tip **26** relative to touch-sensitive display **54** is detected by touch-sensitive device **52** through changes in the net charge on sense lines as active stylus **20** moves. In particular embodiments, motion of tip **26** relative to touch-sensitive display **54** is determined by correlating information about the location of active stylus **20** with the points in time active stylus **20** was at that location. In particular embodiments, active stylus **20** may be oriented at any suitable angle with respect to touch-sensitive display **52**. As an example, FIG. **6**B illustrates the body of active stylus **20** contacting touch-sensitive display **54** and tip **26** separated from touch-sensitive display **54** by a distance D**2**.

In particular embodiments, high-voltage signals transmitted from one or more electrodes in an active stylus to a touch-sensitive device when the active stylus is in contact with the device may communicate information about the type of contact. As an example, a touch-sensitive device may differentiate contact from an active stylus from contact by another body, such as a finger. In FIG. **7**, tip **26** of active stylus **20** has one or more electrodes capable of transmitting high-voltage signals. Touch-sensitive device **52** has drive lines capacitively coupled to sense line. Touch-sensitive device **52** may periodically scan drive lines by increasing the ordinary voltage V**0** of the drive lines to a scanning voltage Vdrive, as illustrated in graph **64**. Vdrive induces net charge on sense lines capacitively coupled to the drive lines. Touch-sensitive device **52** detects contact from a body, such as a finger or palm of hand **62**, by detecting reduced net charge on sense lines. Active stylus **20** may reduce net charge on sense lines and thus simulate contact from a body such as hand **62** by detecting the drive voltage Vdrive, inverting it, and transmitting the inverted voltage as a high-voltage (relative to the ordinary voltage Vnormal active stylus **20** uses) signal Vhigh− to the touch-sensitive device. Graph **66** illustrates an example high-voltage signal active stylus **20** uses to simulate contact from a body such as hand **62**. Active stylus **20** also may differentiate its contact with touch-sensitive display **54** from contact by hand **62** by increasing the net change on sense lines capacitively coupled to drive lines driven with voltage Vdrive. Active stylus **20** does so by detecting the drive voltage Vdrive and transmitting it as a high-voltage (relative to the ordinary voltage Vnormal active stylus **20** uses) signal Vhigh+ back to touch-sensitive display **54**. Graph **68** illustrates an example high-voltage signal active stylus **20** uses to differentiate its contact from that of a body such as hand **62**. While this disclosure describes transmitting information about contact of an active stylus with a touch-sensitive device by transmitting particular high-voltage signals from the active stylus detected by particular components in a touch-sensitive

device, this disclosure contemplates any suitable high-voltage signals transmitted from an active stylus and detected by any suitable components in a touch-sensitive device.

Herein, reference to a computer-readable non-transitory storage medium encompasses a semiconductor-based or other integrated circuit (IC) (such, as for example, a field-programmable gate array (FPGA) or an application-specific IC (ASIC)), a hard disk drive (HDD), a hybrid hard drive (HHD), an optical disc, an optical disc drive (ODD), a magneto-optical disc, a magneto-optical drive, a floppy disk, a floppy disk drive (FDD), magnetic tape, a holographic storage medium, a solid-state drive (SSD), a RAM-drive, a SECURE DIGITAL card, a SECURE DIGITAL drive, or another suitable computer-readable non-transitory storage medium or a combination of two or more of these, where appropriate. A computer-readable non-transitory storage medium may be volatile, non-volatile, or a combination of volatile and non-volatile, where appropriate.

Herein, "or" is inclusive and not exclusive, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A or B" means "A, B, or both," unless expressly indicated otherwise or indicated otherwise by context. Moreover, "and" is both joint and several, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A and B" means "A and B, jointly or severally," unless expressly indicated otherwise or indicated otherwise by context.

This disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Moreover, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, component, whether or not it or that particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative.

What is claimed is:

1. A stylus comprising:
one or more electrodes;
one or more computer-readable non-transitory storage media embodying logic for transmitting signals wirelessly to a device through a touch sensor of the device, at least some of the signals comprising high-voltage signals associated with a high voltage comprising a relatively large potential difference compared to a voltage within a voltage range of approximately 1 to approximately 3 volts;
a component operable to convert the voltage of approximately 1 to 3 volts to the high voltage; and
a stylus tip, one or more of the one or more electrodes being disposed at the stylus tip;
wherein the high-voltage signals result from the one or more electrodes receiving the high voltage.

2. The stylus of claim **1**, wherein the component is a transformer.

3. The stylus of claim **1**, wherein the high voltage comprises a voltage within the voltage range of approximately 10 to approximately 20 volts.

4. The stylus of claim **1**, wherein the high-voltage signals identify a location of the stylus relative to the touch sensor of the device.

5. The stylus of claim **1**, wherein, when the stylus is in contact with or in the proximity of the touch sensor of the device, the high-voltage signals are used to simulate or distinguish:
contact by an object other than the stylus with the device; or
a presence of the object near the touch sensor of the device.

6. The stylus of claim **5**, wherein the object is least a part of a human hand.

7. The stylus of claim **5**, wherein the high-voltage signals are based on a voltage used by at least a portion of the touch sensor of the device.

8. A stylus comprising:
one or more electrodes;
one or more computer-readable non-transitory storage media embodying logic for transmitting electromagnetic signals wirelessly to a device through a touch sensor of the device, at least some of the signals comprising high-voltage signals associated with a high voltage comprising a relatively large potential difference compared to a voltage within a voltage range of approximately 1 to approximately 3 volts, the high voltage based on a voltage difference between a drive line of the touch sensor and a sense line of the touch sensor; and
a stylus tip, one or more of the one or more electrodes being disposed at the stylus tip;
wherein the high-voltage signals result from the one or more electrodes receiving the high voltage.

9. The stylus of claim **8**, wherein the high voltage is produced by a transformer in the stylus.

10. The stylus of claim **8**, wherein the high voltage comprises a voltage within the voltage range of approximately 10 to approximately 20 volts.

11. The stylus of claim **8**, wherein, when the stylus is in contact with or in the proximity of the touch sensor of the device, the high-voltage signals are used to simulate or distinguish:
contact by an object other than the stylus with the device; or
a presence of the object near the touch sensor of the device.

12. The stylus of claim **11**, wherein the object is least a part of a human hand.

13. The stylus of claim **11**, wherein the high voltage has the same polarity as the voltage difference between the drive line of the touch sensor and the sense line of the touch sensor.

14. The stylus of claim **11**, wherein the high voltage has the opposite polarity as the voltage difference between the drive line of the touch sensor and the sense line of the touch sensor.

15. One or more non-transitory computer-readable storage media embodying logic that is operable when executed to:
transmit electromagnetic signals from a stylus to a device through a touch sensor of the device, at least some of the electromagnetic signals comprising high-voltage signals associated with a high voltage comprising a relatively large potential difference compared to a voltage within a voltage range of approximately 1 to approximately 3 volts, the stylus comprising:
one or more electrodes for wirelessly transmitting the signals to the device;
a component operable to convert the voltage of approximately 1 to 3 volts to the high voltage; and

a stylus tip, one or more of the one or more electrodes being disposed at the stylus tip;

wherein the high-voltage signals result from the one or more electrodes receiving the high voltage.

16. The media of claim **15**, wherein the component is a transformer.

17. The media of claim **15**, wherein the high voltage is based on a voltage difference between a drive line of the touch sensor and a sense line of the touch sensor.

18. The media of claim **17**, wherein, when the stylus is in contact with or in the proximity of the touch sensor of the device, the high-voltage signals are used to simulate or distinguish:

contact by an object other than the stylus with the device; or

a presence of the object near the touch sensor of the device.

19. The media of claim **18**, wherein the high voltage has the same polarity as the voltage difference between the drive line of the touch sensor and the sense line of the touch sensor.

20. The media of claim **18**, wherein the high voltage has the opposite polarity as the voltage difference between the drive line of the touch sensor and the sense line of the touch sensor.

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