(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 August 2013 (15.08.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/117815 A1

(51) International Patent Classification:
G06F 3/044 (2006.01)

(21) International Application Number:
PCT/FI2013/050129

(22) International Filing Date:
6 February 2013 (06.02.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/595,309 6 February 2012 (06.02.2012) US

(71) Applicant: **CANATU OY** [FI/FI]; Konalankuja 5, FI-00390 Helsinki (FI).

(72) Inventors: **RUUSUNEN, Matti, Hannu**; Kilonpurontie 6 D, FI-02610 Espoo (FI). **VON PFALER, Jan**; Lapinlahdenkatu 23 B 25, FI-00180 Helsinki (FI). **MIKLADAL, Bjørn, Friður**; Aleksis Kiven katu 58 B 51, FI-00510 Helsinki (FI). **AITCHISON, Bradley, J.**; Tukkitie 17 C, FI-00760 Helsinki (FI). **BROWN, David, P.**; Kapteeninkatu 4 E 21, FI-00140 Helsinki (FI).

(74) Agent: **PAPULA OY**; P.O.Box 981, FI-00101 Helsinki (FI).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: A TOUCH SENSING DEVICE AND A DETECTION METHOD

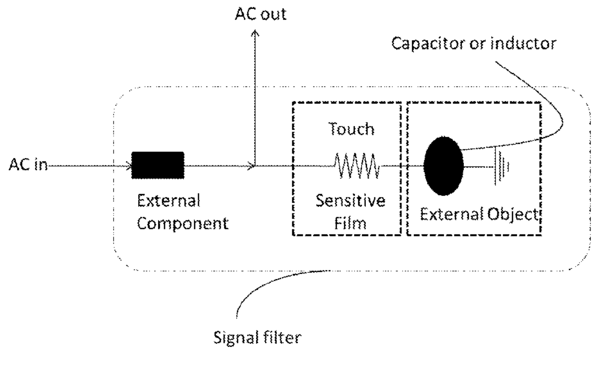


Figure 1a

(57) **Abstract**: A touch sensing device, comprising: a touch sensitive film, a signal filter, electrical circuitry and a processing unit. According to the invention, the film is capable of capacitive or inductive coupling to an external object when a touch is made by the object. The signal filter is formed at least by the resistance of the film and the capacitive or inductive coupling to the external object,and the filter has properties affected at least by location of the touch and/or capacitance or inductance of the touch. The electrical circuitry is coupled to the touch sensitive film at one or more locations and configured to supply one or more excitation signals at least one frequency, amplitude and wave form into the signal filter and to receive one or more response signals from the signal filter. The processing unit is coupled to the electrical circuitry and is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance and/or inductance of said touch by processing one or more response signals and thereby measuring changes in the properties of the signal filter.

WO 2013/117815 A1

A TOUCH SENSING DEVICE AND A DETECTION METHOD

FIELD OF THE INVENTION

The present invention relates to touch sensing devices, more particularly to touch sensing devices having touch sensitive films, and to a method of detecting a touch and detecting its location.

BACKGROUND OF THE INVENTION

User interfaces for different kinds of electrical apparatuses are nowadays more and more often made with different types of touch sensing devices based on touch sensitive films instead of conventional mechanical buttons. Well known examples include different kinds of touch pads and touch screens in mobile phones, portable computers and similar devices. In addition to the sophisticated and even luxurious user experience achievable, touch sensing devices based on touch sensitive films also provide a superior freedom to the designers continuously trying to find functionally more versatile, smaller, cheaper, lighter, and also visually more attractive devices.

A key element in such touch sensing devices is a touch sensitive film comprising one or more conductive layers configured to serve as one or more sensing electrodes. The general operating principle of this kind of film is that the touch of a user by, e.g. a fingertip or some particular pointer device is detected by means of measuring circuitry to which the touch sensitive film is connected. The actual measuring principle can be e.g. resistive or capacitive, the latter one being nowadays usually considered the most advanced alternative providing the best performance in the most demanding applications.

Capacitive touch sensing is based on the principle that a touch on a touch sensitive film means, from electrical point of view, coupling an external capacitance to the measurement circuitry to which the touch sensitive film is connected. With sufficiently high sensitivity of the touch sensitive film, even no direct contact on the touch sensitive film is necessitated but a capacitive coupling can be achieved by only bringing a suitable object to the proximity of the touch sensitive film. The capacitive coupling is detected in the signals of the measurement circuitry. In a so called projected capacitive method, the measurement circuitry includes drive electrodes and sense electrodes used for supplying the signal and sensing the capacitive coupling, respectively. This circuitry is also arranged to rapidly scan over the sensing electrodes sequentially so that coupling between each supplying/measuring electrode pair is measured.

Common for the known touch sensitive films in the projected capacitive method is that the need to properly determine the location of the touch necessitates a high number of separate sensing electrodes in the conductive layers. In other words, the conductive layers are patterned into a network of separate sensing electrodes. The more accurate resolution is desired, the more complex sensing electrode configuration is needed. One particularly challenging issue is the detection of multiple simultaneous touches which, on the other hand, often is one of the most desired properties of the state-of-the-art touch sensing devices. Complex sensing electrode configurations and a high number of single sensing electrode elements complicates the manufacturing process as well as the measurement electronics of the touch sensing device.

In touch screens, in addition to the touch sensing capability, the touch sensitive film must be optically transparent to enable use of the film in or on top of a display of an electronic device, i.e. to enable the display of the device to be seen through the touch sensitive film. Moreover, transparency is also very important from the touch sensitive film visibility point of view. Visibility of the touch sensitive film to the user of e.g. an LCD (Liquid Crystal Display), an OLED (Organic Light Emitting Diode) display, or an e-paper (electronic paper) display seriously deteriorates the user experience. So far, transparent conductive oxides like ITO (Indium Tin Oxide) have formed the most common group of the conductive layer materials in touch sensitive films. However, from the visibility point of view, they are far from an ideal solution. The high refractive index of e.g. ITO makes the patterned sensing electrodes visible. The problem is emphasized as the sensing electrode patterning becomes more complicated.

One promising new approach in touch sensitive films is found in layers formed of or comprising networked nanostructures. In addition to a suitable conductivity performance, a layer consisting of networks of e.g. carbon nanotubes (CNT), or carbon NANOBUDs having fullerene or fullerene-like molecules covalently bonded to the side of a tubular carbon molecule (NANOBUD® is a registered trade mark of Canatu Oy), can be made less visible to a human eye than e.g. transparent conductive oxides like ITO, ATO or FTO. Besides, as is well known, nanostructure-based layers can possess flexibility, mechanical strength and stability superior in comparison with e.g. transparent conductive oxides.

One nanostructure-based solution is reported in US 2009/0085894 A1. According to the description thereof, the nanostructures can be e.g. different types of carbon nanotubes, graphene flakes, or nanowires. Doping of the film is mentioned as a means for increasing the electrical conductivity thereof. Two-layer configurations based on mutual capacitance and single-layer self-capacitance approaches are discussed there. Multiple touch detection is stated to be possible by means of the films disclosed. However, the common problem of very complex electrode and measurement circuitry configurations is not solved in this document.

Another prior art solution is suggested in WO 2011/107666 A1. It discloses a touch sensing device having a touch sensitive film, e.g. made of a network of nanostructures, the film having sheet resistance above 3.0 kΩ. While the problem of complex circuitry is addressed in that invention, it still only suggests operating with high resistance films and at limited frequency ranges.

There is a need to provide a versatile touch sensing device that has a simple sensing electrode configuration, preferably enables single-layer capacitive operation principle, can operate at a wide range of conductive film resistances, enables signal frequency tuning for better noise control, and allows using a wide variety of sensing algorithms.

PURPOSE OF THE INVENTION

The purpose of the present invention is to provide novel solutions that have at least some or all the above-mentioned advantages.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a touch sensing device, comprising: a touch sensitive film comprising conductive material having a resistance, the film being capable of capacitive or inductive coupling to an external object when a touch is made by said external object; a signal filter formed at least by the resistance of the touch sensitive film and the capacitive or inductive coupling to the external object, the signal filter having properties that are affected at least by the location of the touch, the capacitance or inductance of the touch or by a combination of said properties of the touch; electrical circuitry resistively or wirelessly coupled to the touch sensitive film at one or more locations, the electrical circuitry being configured to supply one or more excitation signals having at least one frequency into the signal filter and to receive one or more response signals from the signal filter; and a processing unit resistively or wirelessly coupled to the electrical circuitry, wherein the processing unit is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof by processing one or more response signals and thereby measuring changes in the properties of the signal filter.

A touch sensitive film means, in general, a film which can be used as a touch sensitive element in a touch sensing device. A touch sensing device is to be understood here broadly to cover all user interface devices operated by touching the device by an external object, as well as other types of devices for detecting the presence, proximity and location of such objects.

The touch sensitive film of the present invention is capable of capacitive or inductive coupling to an external object, which means that a touch by an external object causes changes in the filtering properties of the film.

The word “touch” and derivatives thereof are used in the context of the present invention in a broad sense covering not only a direct mechanical or physical contact between the fingertip, stylus, or some other pointer or object and the touch sensitive film, but also situations where such an object is in the proximity of the touch sensitive film so that the object generates sufficient capacitive or inductive coupling between the touch sensitive film and the ambient, or between different points of the touch sensitive film. In this sense, the touch sensitive film of the present invention can also be used as a proximity sensor.

By “conductive material” is meant here any material capable of allowing flow of electric charge in the material, irrespective of the conductivity mechanism or conductivity type of the material. Thus, conductive material covers here, for instance, also semiconductive or semiconducting materials. There can be one or more layers of conductive material in a touch sensitive film.

In addition to the conductive material, the touch sensing device can also comprise other layers of material and structures needed to implement an entire working touch sensitive element. For example, there can be one or more layers for mechanical protection of the film. Moreover, there can be also one or more layers for refractive index or color matching, and/or one or more coatings, for instance, for anti-scratch, decorative, water repellant, self-cleaning, or other purposes. Besides the layered elements, the touch sensitive film can also comprise three-dimensionally organized structures, e.g. contact structures extending through the touch sensitive film or a portion thereof.

A signal filter is formed at least by the touch sensitive film resistance and the capacitive or inductive coupling to an external object. This signal filter can be e.g. a low-pass filter, a high-pass filter, a band-stop or band-pass filter. An example of a low-pass filter would be an RC (resistor-capacitor) series circuit across the input, with the output taken across the capacitor. In an exemplary embodiment of the present invention, the film resistance could represent R and the capacitive coupling created by the touch could represent C in the above low-pass filter.

By an "external object" is meant any capacitor or inductor or capacitive or inductive pointer, e.g. a human finger or a metal stylus, pointers having a capacitive element or a metallic coil for inductive coupling etc. For example, a stylus with a coil can be either passive (no current is actively applied to the coil) or active (an AC or DC current is applied to the coil). A stylus with an active coil is generally used to improve the accuracy, response time, or transparency of the touch.

Forming of a signal filter by the resistance of the touch sensitive film and the coupling to the external object is based on an observation by the inventors that such a filter changes its properties in response to a touch from an external object, and that this change can be measured to detect the touch, its location and determine the capacitance or inductance of the touch with a very high precision.

The electrical circuitry according to this embodiment is resistively or wirelessly coupled to the touch sensitive film at one or more locations. The circuitry can comprise different types of contact electrodes, wirings and other forms of conductors, switches, and other elements needed to connect the touch sensitive film and the one or more conductive layers thereof to the rest of the touch sensing device. Resistive connection implies physical contact, while e.g. radio wave, inductive or capacitive coupling relates to wireless coupling. Examples of resistive coupling include but are not limited to soldering, clamps or other traditional techniques.

The electrical circuitry is configured to supply one or more excitation signals to the signal filter, and to receive one or more response signals from the filter. The electrical circuitry is connected to a processing unit, as described below. In an exemplary embodiment of the invention, the signals are sent to the filter and received from it by the processing unit via the electrical circuitry. The supplied one or more excitation signals have at least one frequency, amplitude and wave form. This means that each signal may vary in frequency, amplitude or wave form or have a constant frequency, amplitude and wave form, and, in case of multiple signals, they may have equal or different frequencies, amplitudes and wave forms. In practice, electrical circuitry together with the processing unit may be partly or fully integrated to a single chip.

An excitation signal can be any electrical signal, e.g. a pulsed, rise and fall time limited or oscillating voltage or current, supplied to the signal filter of the touch sensitive film via the circuitry and providing conditions suitable for monitoring the changes a touch induces in the filter properties. The excitation signal could also be called, for example, a drive signal or a stimulation signal. Typical examples are AC current and/or voltage. A response signal is correspondingly any measured electrical signal received from the signal filter by using the circuitry and allowing detection of a touch on the basis of changes the touch causes to the filter properties and detectable by this signal.

In an embodiment, the processing unit is resistively or wirelessly coupled to the electrical circuitry. The processing unit is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof by processing one or more response signals and thereby measuring changes in the properties of the signal filter.

The processing unit can comprise a processor, a signal or pulse generator, a signal comparer, an interpretation unit, and other hardware and electronics as well as software tools necessary to process the response signals.

The touch sensing device is capable of operation in a single-layer mode utilizing a touch sensitive film having one single conductive layer only. This is an advantageous simplification in comparison with most prior art capacitive touch sensitive films utilizing a two-layer approach using different conductive layers for the excitation and the response signals.

According to an embodiment, the electrical circuitry is configured to receive one or more response signals from the signal filter. In this embodiment, the processing unit is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof, by comparing said response signals to each other and thereby measuring changes in the properties of the signal filter. In an alternative embodiment, the processing unit is configured to compare the response signals to the excitation signals to measure changes in the properties of the signal filter.

In an embodiment, an alternating current or voltage is provided as an excitation signal to the signal filter at one point thereof and alternating voltage or current as a response signal is measured at another point of the filter.

In an embodiment, the signal filter is further formed by at least one external component. This at least one external component is a part of the touch sensing device of the above embodiments and it is resistively or wirelessly coupled to the processing unit via the electrical circuitry. The external component can be a resistor, constant current source, capacitor or inductor or a combination thereof. This external component can be integrated into other units in the device.

In an embodiment, an alternating current or voltage is provided as an excitation signal to the signal filter through an external component at one point thereof and alternating voltage or current as a response signal is measured at the same point of the filter.

According to an embodiment, the properties of the signal filter are further affected by the distance between said external object and the sensing film, the capacitance or inductance of the external object, physical properties of said external object, the resistance of the film, the existence, thickness or dielectric constant of a dielectric or insulating layer between the sensitive film material and the external object, or by a combination thereof.

The physical properties of the external object include e.g. its geometry, material, orientation and configuration.

According to an embodiment, the electrical circuitry comprises one or more electrodes, and wherein at least one of the electrodes is configured to supply said excitation signal into the signal filter, and at least one of the electrodes is configured to receive said electrical response signal from the signal filter. The number of the electrodes may vary depending on the structure.

In one preferred embodiment, the measured properties of the signal filter include amplitude response, phase response, voltage response, current response or a combination thereof. These properties can be affected by the presence or proximity of a touch, its location and its capacitance or inductance.

According to a preferred embodiment of the present invention, the processing unit is further configured to select one or more properties to be measured based on at least one pre-determined frequency, amplitude and wave form of the excitation signal so as to maximize the signal to noise ratio and/or improve the accuracy of the device at the pre-determined frequency, amplitude and wave form.

An optimal excitation frequency depends on many factors. Noise may increase at lower frequencies. On the other hand, antenna effects disturbing the touch detection becomes a problem at very high frequencies. Antenna effects mean that different parts of the measurement circuitry act like antennas tending to couple disturbance signals between the circuitry and the ambient. There usually is an optimal frequency range between a lower and an upper cut-off frequency. This range depends, for example, on the resistance of the conductive material in the touch sensitive film, the thickness and dielectric constant of any coating layer over the film, the capacitance or inductance of the external object, the frequencies of the surrounding electronics and the material of the substrate on which the conductive film lies. For example, with a sufficient high frequency, a PET substrate becomes conductive, thereby interfering with the excitation and response signals. Therefore, the ability to choose the operating frequency range, to actively tune the frequency based on those factors affecting the optimal frequency and to adjust the device accordingly (i.e. by choosing the filter property to be measured or the particular excitation frequency within the operating range) is provided.

According to an embodiment, the touch sensitive film of the touch sensing device extends as a continuous structure in a plane. This means that the touch sensitive film extends, for example, as solid, non-interrupted, and non-patterned structure substantially over the entire sensing area of the touch sensing device, though, as in the case of, for instance, HARM networks, the structure is not strictly continuous at the nano or micro scale. This structure is also optionally homogenous. This feature not only minimizes the visibility of the conductive layer but also simplifies the manufacturing thereof when no patterning of the layer is needed. It also simplifies the electronics of a touch sensing device having a touch sensitive film according to this embodiment.

The good sensitivity and touch location resolution performance of the touch sensitive film enable use of such a non-patterned conductive layer in a single-layer operation mode. Operation in a single-layer mode means that only one single conductive layer is used in touch sensing measurements. Multi-touch detection capability is also available in a non-patterned single-layer operation mode. Single-layer capability as such also allows producing the entire touch sensitive film as a rather thin structure.

In one embodiment, the touch sensitive film comprises: a single stripe or two or more parallel stripes made of the conductive material and extending over the touch sensitive film in one direction and areas between said stripes comprising non-conducting material, wherein the electrical circuitry is resistively or wirelessly coupled to each of the stripes, and the processing unit is further configured to detect the presence, proximity and location of the touch along each stripe.

The electrodes of the electrical circuitry are coupled to each stripe to supply and receive signals for measurement. The touch location has to be determined only in one dimension, and it is possible to use only one electrode per stripe to do so.

In one embodiment, the touch sensitive film is formed as a flexible structure so as to allow bending thereof. A “flexible” structure means here a structure allowing bending of the film, preferably repeatedly, in at least one direction. In an embodiment, the touch sensitive film is flexible in at least two directions simultaneously.

Instead of or in addition to the flexibility, the touch sensitive film can also be formed as a deformable structure so as to allow deforming thereof, e.g. by using thermoforming, along or over a three dimensional surface.

Flexibility and/or deformability of the touch sensitive film in combination with the measurement features open entirely novel possibilities to implement touch sensing devices. For example, a touch sensitive film serving as the user interface of a mobile device can be bent or formed to extend to the device edges so that the touch sensitive film can cover even the entire surface of the device. In a touch sensitive film covering different surfaces of a three-dimensional device, there can be several touch sensing regions for different purposes. One sensing region can cover the area of a display to form a touch screen. Other sensing regions e.g. at the sides of the device can be configured to serve as touch sensitive element replacing the conventional mechanical buttons, e.g. the power button or volume or brightness sliders or dials.

A good choice for flexible and/or deformable touch sensitive films is a conductive layer comprising one or more HARMS (High Aspect Ratio Molecular Structure) networks, as described in more detail below. HARM structures and the networks thereof are inherently flexible, thus enabling making the touch sensitive film bendable and/or deformable.

Preferably, the touch sensitive film is optically transparent, thus enabling use of the touch sensitive film e.g. as part of a touch screen. Optical transparency of the touch sensitive film means here that at least 10 %, preferably at least 90 % of the incident radiation from a direction substantially perpendicular to the plane of the film, at the frequency/wavelength range relevant in the application at issue, is transmitted through the film. In most touch sensing applications, this frequency/wavelength range is that of visible light.

For the optical transparency, the key is the conductive material of a touch sensitive film. The requirement of simultaneous electrical conductivity and optical transparency limits the number of possible materials. In this sense, HARMS networks form a good basis for an optically transparent touch sensitive film because the HARMS networks can provide a transparency superior to that of the transparent conductive oxides, for example.

In one embodiment, the touch sensitive film comprises a High Aspect Ratio Molecular Structure (HARMS) network, a conductive polymer, graphene or a ceramic, grids of metal such as silver or gold, or metal oxide. By HARMS or HARM structures is meant here electrically conductive structures with characteristic dimensions in nanometer scale, i.e. dimensions less than or equal to about 100 nanometers. Examples of these structures include carbon nanotubes (CNTs), carbon NANOBUDs (CNBs), metal nanowires, and carbon nanoribbons. In a HARMS network a large number of these kinds of single structures, e.g. CNTs, are interconnected with each other. In other words, at a nanometer scale, the HARM-structures do not form a truly continuous material, such as, e.g., the conductive polymers or Transparent Conductive Oxides, but rather a network of electrically interconnected molecules. However, as considered at a macroscopic scale, a HARMS network forms a solid, monolithic material. HARMS networks can be produced in the form of a thin layer.

The advantages achievable by means of the HARMS network(s) in the sensitive film include excellent mechanical durability and high optical transmittance useful in applications requiring optically transparent touch sensitive films, but also very flexibly adjustable electrical properties. To maximize these advantages, the conductive material can substantially consist of one or more HARMS networks.

The resistivity performance of a HARMS network is dependent on the density (thickness) of the layer and, to some extent, also on the HARMS structural details like the length, thickness, or crystal orientation of the structures, the diameter of nanostructure bundles etc. These properties can be manipulated by proper selection of the HARMS manufacturing process and the parameters thereof. Suitable processes to produce conductive layers comprising carbon nanostructure networks are described e.g. in WO 2005/085130 A2 and WO 2007/101906 A1 by Canatu Oy.

In one embodiment of the touch sensing device according to the present invention, the touch sensing device comprises also serves as a haptic interface film. In other words, the device further comprises means for providing a haptic feedback, preferably via the sensitive film, in response to a touch. Providing the haptic feedback via the sensitive film means that, instead of the conventional approach based on separate actuators attached to the touch sensitive film for generating vibration of the touch sensitive film, the sensitive film is used as a part of the means for generating the haptic feedback. There are various possibilities for this. A haptic effect can be achieved by generating suitable electromagnetic field(s) by means of the sensitive film. The skin of the user touching the touch sensitive film senses these fields as different sensations. This kind of approach can be called capacitive haptic feedback system. On the other hand, the sensitive film can alternatively be used, for instance, as a part of an electroactive polymer (artificial muscle) based haptic interface, wherein the sensitive film forms one layer of the interface.

One possibility to perform the both functions, i.e. the touch detection and haptic feedback, is that the sensitive film is alternately coupled to a touch sensing circuitry and to means for producing the signals for haptic feedback so that once a touch is detected during a first time period, a haptic feedback is then provided at a second time period following the first one. The first and second time periods can be adjusted to be so short that the user experiences the device operating continuously.

One or more touch sensitive films can alternatively be used, for instance, in conjunction with a fluidics based haptic interface (as is under commercialization by Tactus Technologies), wherein the touch sensitive film is integrated with the flexible outer haptic film which changes shape due to the pumping of a fluid into flexible reservoirs. One or more touch sensitive films can be on the inner and/or outer surfaces of the flexible outer haptic film. In this case, the touch sensitive film can be continuously coupled to the touch sensing circuitry.

In one embodiment of the touch sensing device according to the present invention, the touch sensing film also serves as a deformation detecting film. This means that the device incorporates means for e.g. sensing bending, twisting and/or stretching of the sensing film. This can be done by measuring changes in the resistance between nodes or by changes in the signal filter properties simultaneously with the touch sensing according to the invention. As the signal filtering properties of the system are a function of the resistivity of the film and, at least for certain materials, including but not limited to HARMs and conductive polymers and in particular nanotubes and NANOBUDs and more specifically, carbon nanotubes and NANOBUDs, the signal filter properties can change if the film is e.g. stretched, compressed or otherwise deformed. By interpreting this change in either the resistivity or signal filter properties, the present invention can detect, for instance, elongation or compression between nodes connected to the sensor film. Thus, for example, sensing of elongation between two sets of nodes at opposite corners indicates bending, while sensing elongation in one direction and compression in the other indicates twisting. In some configurations, one or more nodes can be used to sense in multiple directions. Alternative configurations are possible according to the invention.

For certain deformable external objects, the capacitance or inductance changes with the force applied to the touch sensitive film and thus the determined capacitance or inductance can be used as a proxy for force. The force means e.g. a force which a user applies to the device when performing a touch. A human finger, for instance, deforms upon the application of a force resulting in increased area in proximity to the sensor film. This will cause the capacitance to change accordingly. Alternatively, if an inductive external object is used, and the user deforms, for instance, a coil of the external object or changes the distance from the coil to the surface (e.g. via a spring), inductance changes accordingly and force can be measured as well.

The touch sensing device of the present invention can be implemented as a standard or customized stand-alone module or as an non-separable unit integrated as a part of some larger device, e.g. a mobile phone, portable or tablet computer, e-reader, electronic navigator, gaming console, refrigerator, blender, dishwasher, washing machine, coffee machine, stove, oven or other white goods surface, car dashboard or steering wheel, etc.

According to one embodiment of the present invention, the wireless coupling between parts of the device is one of the following: coupling by radio waves, coupling through magnetic fields, inductive or capacitive coupling.

By “the wireless coupling between parts of the device” is meant a wireless coupling between any device elements described above.

The setup may require supplemental electronics that handle the creation, sending and receiving of the data and the AC current that creates either electrostatic or electrodynamic induction between electrodes that are located on both the main device and the touch sensing module. These two devices may be wirelessly coupled together by one or more of the following methods:

- Electromagnetic induction (Inductive coupling, electrodynamic induction), where the data and power transmission is induced by current from a magnetic field between opposing coils.
- Magnetic resonance is near field electromagnetic inductive coupling through magnetic fields.
- Radio waves (e.g. RFID technology), wherein the power is generated from the radio waves received by the antenna, and the data transmission substantially changes the radiated field load.
- Capacitive coupling (or electrostatic induction), wherein the energy and data are transferred from opposing planes of electrodes.

Touch sensors can be fully or partly integrated to the application devices either by wires, directly soldered or via connectors. This is sufficient in fixed installations where the sensors typically are positioned in areas that are not required to be open apart. E.g. in portable devices they are typically found in touch display applications, wherein the display is actually beneath the touch sensing film and the screen itself is permanently attached to the device. If a touch sensing device is located on a removable part of a device, then it would typically require a connector by which it could connect to the device once it is attached to it. This method is functional but it may not be suitable in certain applications. Moreover, even if a touch component is intended to be permanently affixed to a device, there are manufacturing costs and design limitations associated with connecting the component via solder or connectors.

In one embodiment of the present invention, a touch sensing device is provided. It comprises a touch sensing module comprising a touch sensitive film, electrical circuitry configured to supply one or more excitation signals to the touch sensing module and to receive one or more response signals from the touch sensitive module. In accordance with this embodiment, the electrical circuitry is coupled to the touch sensing module wirelessly.

In an embodiment, a 2- and 3-dimensional touch sensor devices are provided to applications whose enclosure cover has to be removed, for example to maintain and change the serviceable parts inside. It is also a robust method to provide data entry method to devices requiring unbroken encapsulation for, for example, wet, explosive or otherwise hazardous environments or where direct connection, as with interconnecting wires, is otherwise impossible, costly or highly inconvenient.

In an embodiment, no physical connector for power and data transmission that is susceptible to dirt, wear and tear or breakage. With no connector there are fewer parts susceptible to contamination, chemical or physical degradation or mechanical damage thus increasing the reliability of the device.

A direct physical contact can be avoided which, if not secured firmly, may have an unintentional disconnection and thus lead to data or power loss. It may function as a remote control device to fixed installations that takes the power from the installation and works as an ad-hoc touch sensor or generic data input output device.

By keeping the touch sensor functionalities in a module and separating it from the main device, they become different serviceable parts that can be produced separately and combined together only at the final assembly. An electrode can be implemented cost-efficiently as a metal area or printed wire on printed circuit board.

According to an embodiment, the touch sensor module and the main device may be physically attached to each other but the power or data or both are transmitted wirelessly between them. In practice, the sensor, excitation and sensing electronics together with the data processing unit so that the whole unit is an independent peripheral plug-in.

According to a second aspect of the present invention there is provided a method for detecting the presence, proximity, location, inductance, capacitance or a combination of these features of an external object with a touch sensing device, the method comprising: supplying one or more electrical excitation signals having at least one frequency, amplitude and wave form into a signal filter formed at least by a resistance of a touch sensitive film in the touch sensing device and a capacitive or inductive coupling of said film with the external object, receiving one or more response signals from the signal filter, and detecting the presence of a touch by the external object, or the location of said touch by processing said one or more response signals and thereby measuring changes in properties of the signal filter.

Touch detection sensitivity and touch location resolution of a touch sensing device do not depend on the properties of signal filter and the processing means performance only. Naturally it is also a matter of, e.g., the contact electrode configuration. On the other hand, the touch location resolution of the touch sensitive film and a touch sensing device utilizing it depend also on the number of the contact locations and the placing of them with respect to each other and the film. These are critical issues particularly in a single-layer approach with a non-patterned conductive layer. Typically, the earlier known devices of this type, described e.g. in US 7,477,242 B2 and US 2008/0048996 A1, rely on a rectangular-shaped conductive layer and four contact electrodes at the corners thereof. However, this configuration necessitates very complex signal processing, and the accuracy of this device is quite low. It is particularly hard to provide a flexible structure according to that solution. Also, the multi-touch capability can be very challenging to achieve with that kind of approach. These difficulties are mitigated or avoided in the present invention.

Below, the present invention is illustrated on the basis of examples with references to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1a, 1b and 1c illustrate one possible configuration of a touch sensing device according to the present invention.

Figures 2a, 2b and 2c illustrate another possible configuration of a touch sensing device according to the present invention.

Figures 3a and 3b are an illustration of a two-dimensional unpatterned touch sensitive film according to an embodiment.

Figures 4a, 4b and 4c show an embodiment having deformation sensing capabilities.

Figure 5 illustrates another embodiment in which a striped touch sensitive film is used.

Figure 6 shows an embodiment having U- and C-shaped stripes in a grid.

Figures 7a and 7b are diagrams of compared received response signals from a touch sensing device according to the present invention.

Figures 8a, 8b and 8c are diagrams of received response signals compared to excitation signals.

DETAILED DESCRIPTION OF THE INVENTION

An explanation of the invention follows based on the examples described below.

Capacitive or inductive coupling to an external object together with a resistive film compose an electronic signal filter. A touch sensitive film with sufficient electrical resistivity together with an external object having capacitance or inductance creates a low-pass RC filter due the resulting RC time constant of the system. The properties of this low-pass filter depend on the sheet resistance, as well as on location and capacitance or inductance of the external object.

In the typical operational mode, one or more oscillating signals or pulses are fed into the filter at one or more locations. In the touch sensitive film, the resistance between any two points on or at the edge of the touch surface is a function of their relative location and the geometry and sheet resistance of the sensor area. The capacitance or inductance in this system is a combination of parasitic capacitance or inductance of the system and the capacitance or inductance formed between the film and coupled external object. A change in the electronic filtering characteristics is substantial when, in addition to the film’s resistivity, there is a load caused by one or more capacitively or inductively coupled touches present in the system. By measuring changes in the mentioned signal or pulse, the change in the electronic filter characteristics can be measured and thus the location of one or more touches can be deduced. By measuring e.g. the change in the current into the sensing film, the capacitance or inductance between the sensor and the external object can be calculated. Likewise, the signal changes per sensing node (the part of the electrical circuitry, connected to the touch sensitive film at a particular location) indicate changes in relative distance to the external object and, by comparing the differences between the response signal at the sensing nodes, together with knowledge of the total current consumption and absolute values at the sensor nodes, the relative position of the touch can be calculated by various algorithms. For instance, the amplitudes of the sampled pulses are in correlation to the touch position and can be used for determining the actual position.

Figure 1a shows an embodiment wherein a signal is supplied to a node and the effect of the low-pass filter is measured via the same node. The system consists of a touch sensitive film having a resistivity and an external object that capacitively or inductively couples to this touch sensing film. The signal or pulse is introduced at a point in the sensitive film, typically at an edge, though it may be introduced anywhere in the film. An external component such as a resistor, constant current source, capacitor or inductor or combination thereof, can be used to, for instance, increase the voltage linearity of the measurement, distribute the current or potential more evenly so as to avoid singularities in the system and allow current or voltage potential to be measured. The external component creates, together with the resistive film and external touch object, a low-pass filter. The signal couples to the load created by the touch film and the external object and, by changing the low-pass filter characteristics of the system, thus altering the signal. The altered signal is sampled (received) between the external component and the touch sensitive film. For measuring multi-touch of two or more external objects the measurement principle is similar to single touch situation with the distinction that instead of one there forms up to two or more parallel paths to the external object capacitance or inductance and the capacitive or inductive coupling increases. The sampled signal is different depending on the location and capacitance or inductance of the external object and the interaction of the signal with the low-pass filter formed by the touch film, the external component and the external object. Using multiple inputs / sensing nodes permits one to more exactly specify the location of the touch and the capacitance or inductance of the external object. In the embodiment, to specify x and y locations and the capacitance or inductance, 3 nodes, that can be used in various possible combinations as input and sensing nodes, are needed for each touch, thus, e.g., for 4 simultaneous touches, 12 input and sensing nodes are needed.

A more general configuration of the embodiment according to Figure 1a is shown on a block diagram of Figure 1b, and a specific embodiment where three signals or pulses are supplied via three external components to three points (nodes) on the touch film are illustrated on Figure 1c. The sampled signals or pulses are then compared to the source signal or pulse or to other sampled signals or pulses to determine the location and/or capacitance or inductance of the external object.

Figure 2a shows an exemplary embodiment wherein a signal is fed to a node and the effect of the low-pass filter is measured in one or more opposing or adjacent nodes. The system comprises a sensitive film having a resistivity and an external object that capacitively or inductively couples to this sensitive film. The signal or pulse is introduced at a point in the sensitive film, typically at an edge (though it may be introduced anywhere) and the altered signal is received at a different location. The received signal is different depending on the location and capacitance or inductance of the external object and the interaction of the signal with the low-pass filter formed by the touch film and the external object. Using multiple sensing nodes for a single or multiple input nodes permits more exact specification of the location of the touch and the capacitance or inductance of the external object. In the embodiment, to specify x and y location and the capacitance or inductance, 3 input and sensing nodes are needed for each touch, thus, e.g., for 4 simultaneous touches, 12 input and sensing nodes are needed.

A more general configuration of the embodiment according to Figure 2a is shown on a block diagram of Figure 2b, and a specific embodiment where three signals or pulses are supplied via three external components to three points (nodes) on the touch film are illustrated on Figure 2c. The sampled signals or pulses are then compared to the source signal or pulse or to other sampled signals or pulses to determine the location and/or capacitance or inductance of the external object.

In figures 1b, 1c, 2b and 2c the box “signal / pulse generator” represents a generator that produces e.g. one or more excitation voltage or current pulses or oscillations (excitation signals) which can be, for instance, sinusoidal, triangular, square or saw-toothed in form. If needed, it may also include other functionality such as a control unit and/or a clock. The “signal comparer” box indicates a device that compares and differentiates excitation and/or response signals and provides this information to the interpretation unit. It can compare, for instance, voltage or current frequency, amplitude, phase shift, or wave shape or form. The “interpretation unit” box represents a unit that processes the signals out of the signal comparer and possibly also uses information from the signal / pulse generator (e.g. from the clock or control functions). If needed, it may also include other functionality such as a control unit and/or a clock. It may also provide information to, for instance, the signal / pulse generator (e.g. from the clock or control functions). In practice, all these functions may be incorporated in a single unit or chip and thus may be not separate.

The excitation signals can be sent to individual nodes and corresponding samples of the response signal can be taken in sequence, or simultaneously. Furthermore, the same or different excitation signals can be sent to the individual nodes. The excitation signals can be from the same or different sources.

Figure 3a is an illustration of an embodiment in which a two dimensional touch sensitive film having multiple input signals or pulses (which can be from a single or multiple sources) is used. In this example, three external components are each placed in series between the source and an essentially two dimensional sensitive film, or a sensitive sheet, and the signals are sampled between the external components and the sensitive film. In the case of no touch, the sampled signals will have a given characteristic form in relation to the properties of the filter. When a touch occurs, the capacitive or inductive coupling to the external object changes the filter characteristics. The relationship between the sampled signals, either to each other or to the input signal, provides information on this change of characteristics and therefore on location and capacitance or inductance of the external object. In the embodiment, to specify x and y location and the capacitance or inductance, 3 input and sensing nodes are needed for each touch, thus, e.g., for 4 simultaneous touches, 12 input and sensing nodes are needed. Thus, figure 3a shows the minimum number of nodes to fully specify a single touch in terms of location and capacitance or inductance. Figure 3b shows another embodiment of the same wherein four external components are each placed in series between the source and an essentially two dimensional sensitive film, or a sensitive sheet, and the signals are sampled between the external components and the sensitive film in order to increase accuracy for a single touch or to, e.g., allow for the determination of the presence of multiple touches. The 2-dimensional touch sensitive film described herein may also be flexible and/or formable to a 3D surface.

Figures 4a-c show examples of sensing film deformation with a single film, in which the sensitive film is alternately coupled to a touch sensing circuitry or algorithm and to a deformation sensing circuitry or algorithm. In this case, at least three nodes are required to perform the measurements. The deformation can be determined by measuring changes in resistance between nodes by a DC voltage level.

In practice, sensor deformation, twisting or bending may impact the touch sensing by changing the active region resistivity that again changes the filter properties. However, in this case the touch sensitive film can still be used at least in a mode wherein the same film serves as a deformation sensor when it is deformed, and as a touch sensor when no deformation is made.

Figure 5 illustrates an embodiment of a two dimensional touch sensor having multiple input signals or pulses (which can be from a single or multiple sources). An external component 51 is placed in series between the source or sources, and either a single or a set of essentially one dimensional sensing films (a single or collection of sensing fingers or stripes 52) and the signals are sampled between the external components and the sensing films. The stripes should have a high aspect ratio for good performance, e.g. the length to width ratio should be greater than 3, or more preferably, greater than 10. The stripes can be, for instance, straight or curved and need not be of constant width. In the case of a single stripe, the embodiment may act as a slider or dial. In the case of no touch the sampled signals will have a given characteristic forms in relation to the properties of the filter. When a touch occurs, the capacitive or inductive coupling to the external object changes the filter characteristics. The relationship between the sampled signals to the input signal thus provides information on the location of the external object and the existence of a touch in any given strip. To also detect the capacitance or inductance of the external object, one or more additional samples can be taken from the film, preferably at the opposite end of the stripe 52. In the embodiment, to specify a touch location along a stripe, e.g. the x location, and the capacitance or inductance of a touch on said stripe, 2 input and sensing nodes are needed for each touch, thus, e.g., for 4 simultaneous touches along any stripe, 8 input and sensing nodes are needed. This can be operated according to both configurations of figure 1a and 2a. The location of a touch in the essentially orthogonal, e.g. y, direction, is determined by identifying the presence of a touch on a particular stripe.

A modification of this configuration is to fabricate each stripe as "U" or "C" shaped such that, in the case of two electrodes per stripe, the electrodes are located on the same side or edge of the touch region. This can increase the accuracy of the device and allows all the contact electrodes to be localized along one edge, thus allowing design freedom and reducing the need for, e.g. bezels one or more edges of the touch area.

The configuration of figure 6 can be used also in a two layer structure, each layer having a set of stripes where the stripes of one layer are oriented so as not to be parallel to the strips of the other layer. Preferably, the orientation is at 90 degrees. In this way a grid structure is formed. Figure 5 shows this configuration in combination with "U" or "C" shaped stripes. Typically the layers should be separated by, e.g., an air gap or insulating or dielectric material. A substrate or and coating can serve as such an insulator or dielectric.

The markers "AC in" and "AC out" in figures 5 and 6 can mean a signal or pulse input and output, respectively.

Figure 7a is a diagram showing a comparison of response signals from a touch on a two-dimensional rectangular touch surface having uniform resistivity and six contact electrodes, two of which are at the centerline edge and opposite each other. The figure shows the difference between response signals between these two contact node when a touch is initially slightly offset to the left from the centerline, then briefly on the centerline but slightly off center toward the top, and then slightly off to right in the end. The graphs show the signal differences between different sensing nodes (receiving electrodes), i.e. the measurements are performed according to the embodiment of claim 4. In the ideal case the difference is zero when the touch is at equal distance and angle from the opposing sensing nodes as is the case for the 2nd and 6th graphs. This clearly shows how the changes in filter properties affect the signal and how e.g. the touch location can be measured.

In Figure 7b the signals of Figure 7a are sampled at fixed intervals as would be the case in real system.

Similarly, as opposed to a difference in response signals at different nodes, the difference between the response signal and the excitation signal can be used to determine changes in the filter properties and thus uniquely determine touch existence, proximity, location and capacitance or inductance of the touch object. Figures 8a-c show response signals compared to excitation signals similarly to figures 7a and b. As it is difficult to visually observe the difference in the signals, figure 8c displays the response vs. excitation signal difference when the touch is removed at the time position 120 μs.

Other properties of the response signal can also be used to identify changes in the filter properties such as the voltage or current wave form or shape, the amplitude or the phase shift. The property or properties to be sampled and used in the determination of the changes in the filter property can be freely chosen so that, e.g. the signal to noise ratio is maximized. Moreover, the excitation signal frequency, wave shape (e.g. sinusoidal, triangular, square, saw-toothed etc.) and amplitude can be chosen to, for instance, avoid interference or maximize signal to noise ratio.

The invention is not limited to the examples described above but the embodiments can freely vary within the scope of the claims.

CLAIMS

1. A touch sensing device, comprising:

- a touch sensitive film comprising conductive material having a resistance, the film being capable of capacitive or inductive coupling to an external object when a touch is made by said external object,

- a signal filter formed at least by the resistance of the touch sensitive film and the capacitive or inductive coupling to the external object, the signal filter having properties that are affected at least by the location of the touch, the capacitance or inductance of the touch or by a combination of said properties of the touch,

- electrical circuitry resistively or wirelessly coupled to the touch sensitive film at one or more locations, the electrical circuitry being configured to supply one or more excitation signals having at least one frequency, amplitude and wave form into the signal filter and to receive one or more response signals from the signal filter, and

- a processing unit resistively or wirelessly coupled to the electrical circuitry, wherein the processing unit is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof by processing one or more response signals and thereby measuring changes in the properties of the signal filter.

2. A touch sensing device according to claim 1, wherein the signal filter is a low-pass filter.

3. A touch sensing device according to any of claims 1 or 2, wherein the electrical circuitry is configured to receive at least two response signals from the

signal filter; and wherein the processing unit is configured to detect the presence of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof by comparing said response signals to each other and thereby measuring changes in the properties of the signal filter.

4. A touch sensing device according to any of claims 1 or 2, wherein the electrical circuitry is configured to receive at least one response signal from the signal filter; and wherein the processing unit is configured to detect the presence of a touch by the external object, the location of said touch, the capacitance or inductance of said touch, or a combination thereof by comparing said response signals to the source signal and thereby measuring changes in the properties of the signal filter.

5. A touch sensing device according to any of claims 1 to 4, further comprising an external component resistively or wirelessly coupled to the processing unit via the electrical circuitry, wherein the signal filter is further formed by said at least one external component.

6. A touch sensing device according to any of claims 1 to 5, wherein the properties of the signal filter are further affected by the distance between said external object and the sensing film, capacitance or inductance of the external object, physical properties of said external object, the resistance of the film, the existence, thickness or dielectric constant of a dielectric or insulating layer between the sensitive film material and the external object, or by a combination thereof.

7. A touch sensing device according to any of claims 1 to 6, wherein the electrical circuitry comprises one or more electrodes, and wherein at least one of the electrodes is configured to supply said excitation signal into the signal filter, and at least one of the electrodes is configured to receive said electrical response signal from the signal filter.

8. A touch sensing device according to any of claims 1 to 7, wherein the properties of the signal filter include amplitude response, phase response, voltage response, current response, signal shape response or a combination thereof.

9. A touch sensing device according to claim 8, wherein the processing unit is further configured to select one or more properties to be measured based on at least one pre-determined frequency, amplitude and wave form of the excitation signal.

10. A touch sensing device according to any of claims 1 to 9, wherein the touch sensitive film extends as a continuous structure in a plane.

11. A touch sensing device according to any of claims 1 to 9, wherein the touch sensitive film comprises:

two or more parallel stripes made of the conductive material and extending over the touch sensitive film in one direction, and

areas between said stripes comprising non-conducting material,

wherein the electrical circuitry is resistively or wirelessly coupled to each of the stripes, and the processing unit is further configured to detect the presence and location of the touch along each stripe.

12. A touch sensing device according to any of claims 1 to 11, wherein the touch sensitive film is formed as a flexible structure so as to allow bending of the touch sensitive film.

13. A touch sensing device according to any of claims 1 to 11, wherein the touch sensitive film is formed as a deformable structure so as to allow deforming of the touch sensitive film to form a three dimensional surface.

14. A touch sensing device according to any of claims 1 to 13, wherein the touch sensitive film is optically transparent.

15. A touch sensing device according to any of claims 1 to 14, wherein the touch sensitive film comprises a high aspect ratio molecular structure (HARMS) network, a conductive polymer, graphene or a ceramic or metal oxide.

16. A touch sensing device according to any of claims 1 to 15, wherein the touch sensitive film also serves as a haptic interface film.

17. A touch sensing device according to any of claims 1 to 16, wherein the touch sensitive film also serves as a deformation detecting film.

18. A touch sensing device according to any of claims 1 to 17, wherein the capacitance or inductance determined by the processing unit is used as a proxy for determining force or relative change in force of the touch.

19. A touch sensing device according to any of claims 1 to 17, wherein the wireless coupling between parts

of said device is one of the following: coupling by radio waves, coupling through magnetic fields, inductive or capacitive coupling.

20. A method for detecting the presence, proximity, location, inductance, capacitance or a combination of these features of an external object with a touch sensing device, the method comprising:

- supplying one or more electrical excitation signals having at least one frequency, amplitude and wave form into a signal filter formed at least by a resistance of a touch sensitive film in the touch sensing device and a capacitive or inductive coupling of said film with the external object,

- receiving one or more response signals from the signal filter, and

- detecting the presence of a touch by the external object, or the location of said touch by processing said one or more response signals and thereby measuring changes in properties of the signal filter.

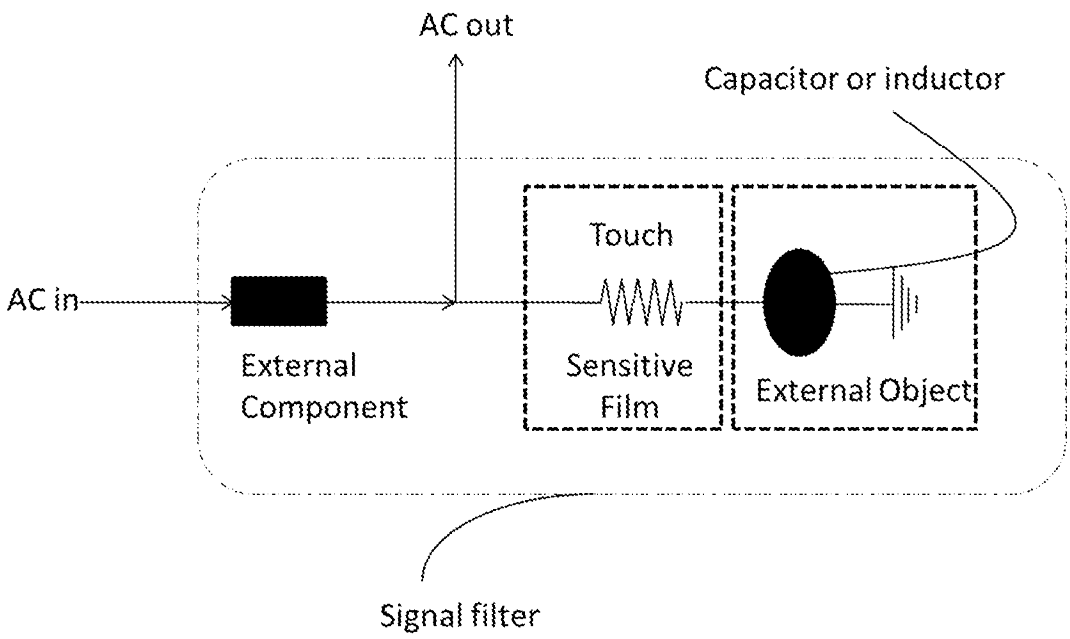


Figure 1a

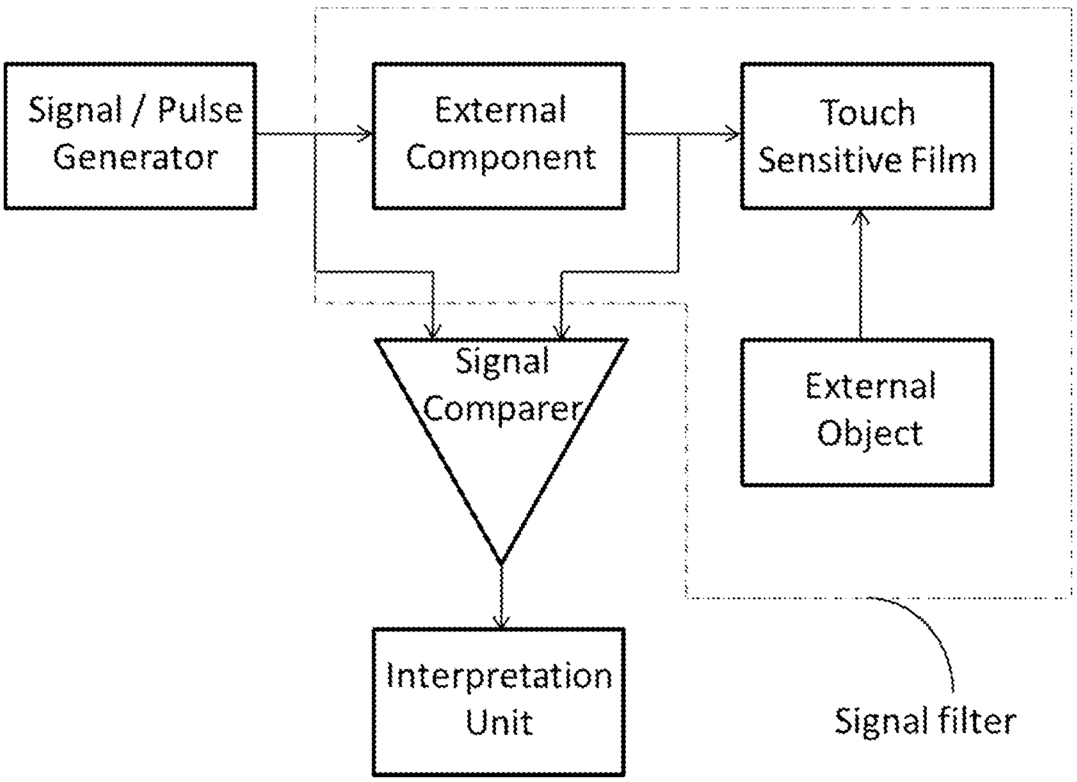


Figure 1b

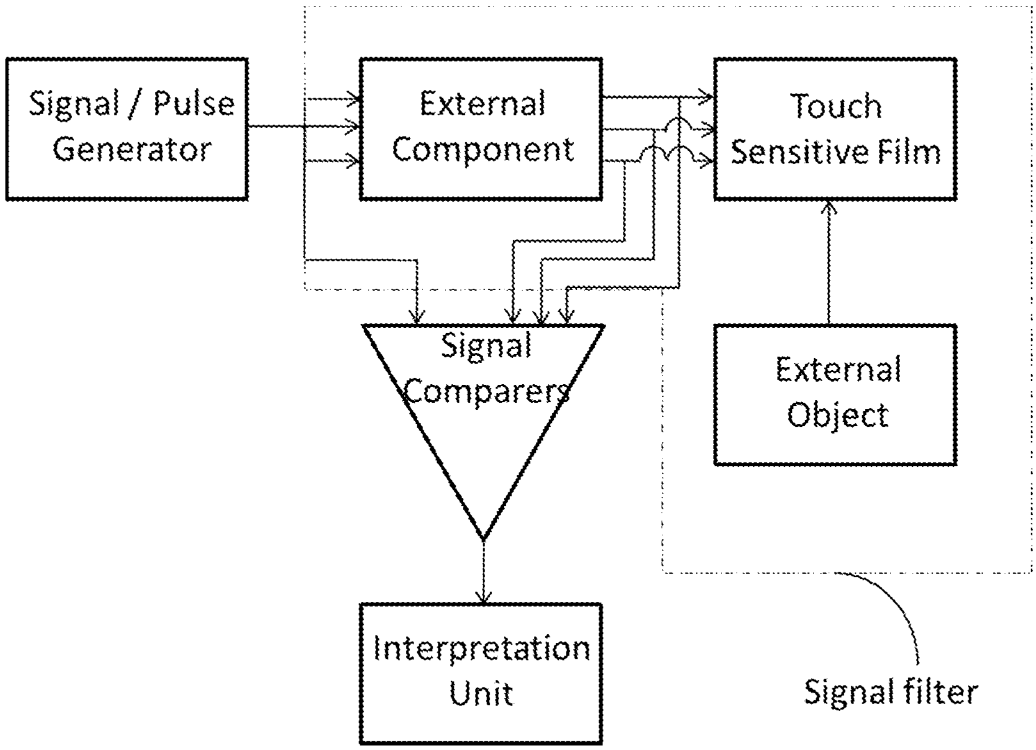


Figure 1c

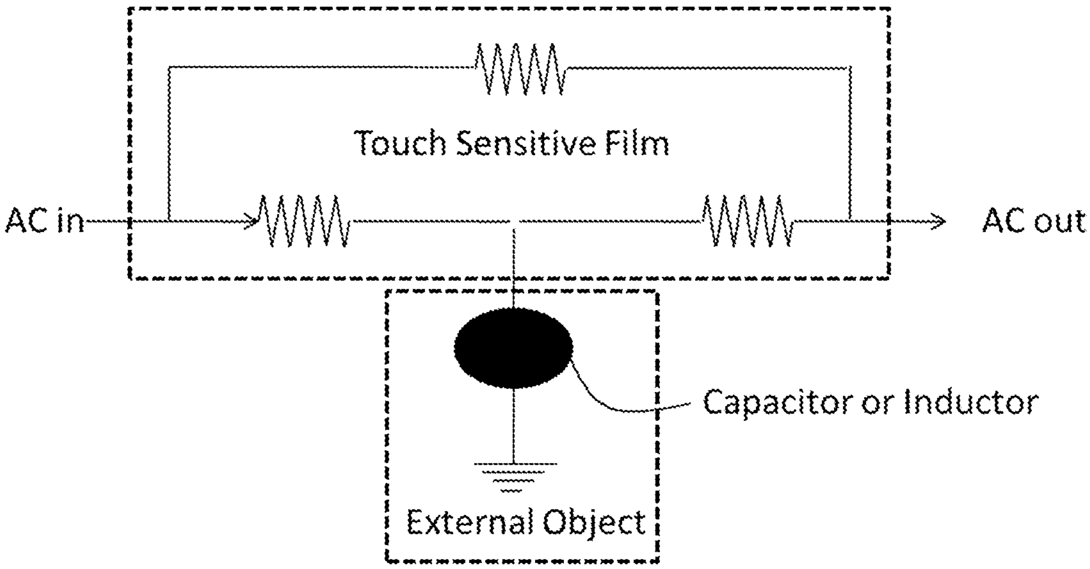


Figure 2a

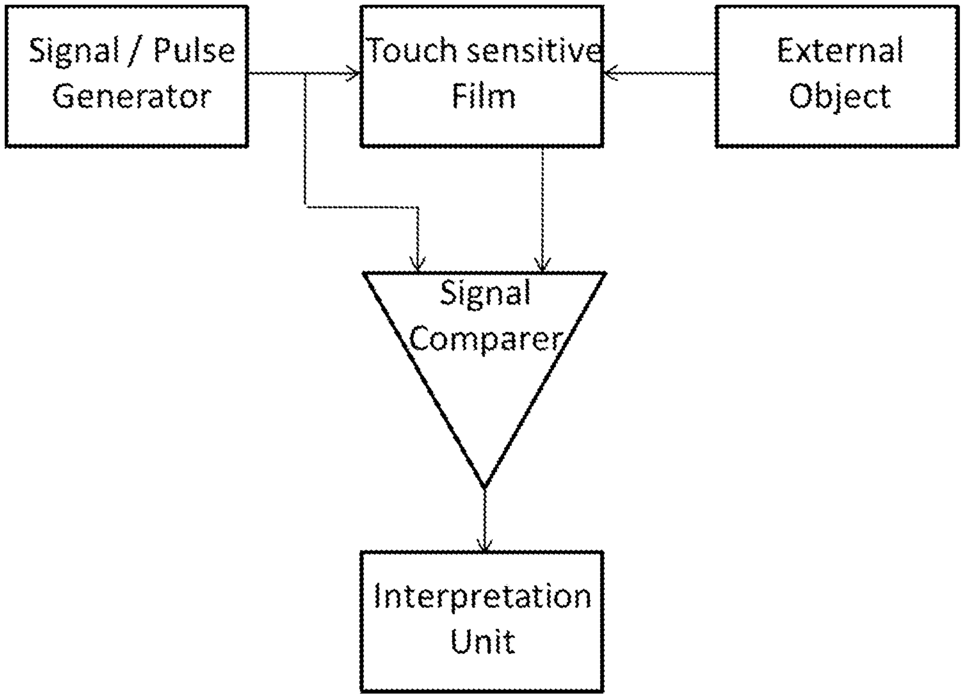


Figure 2b

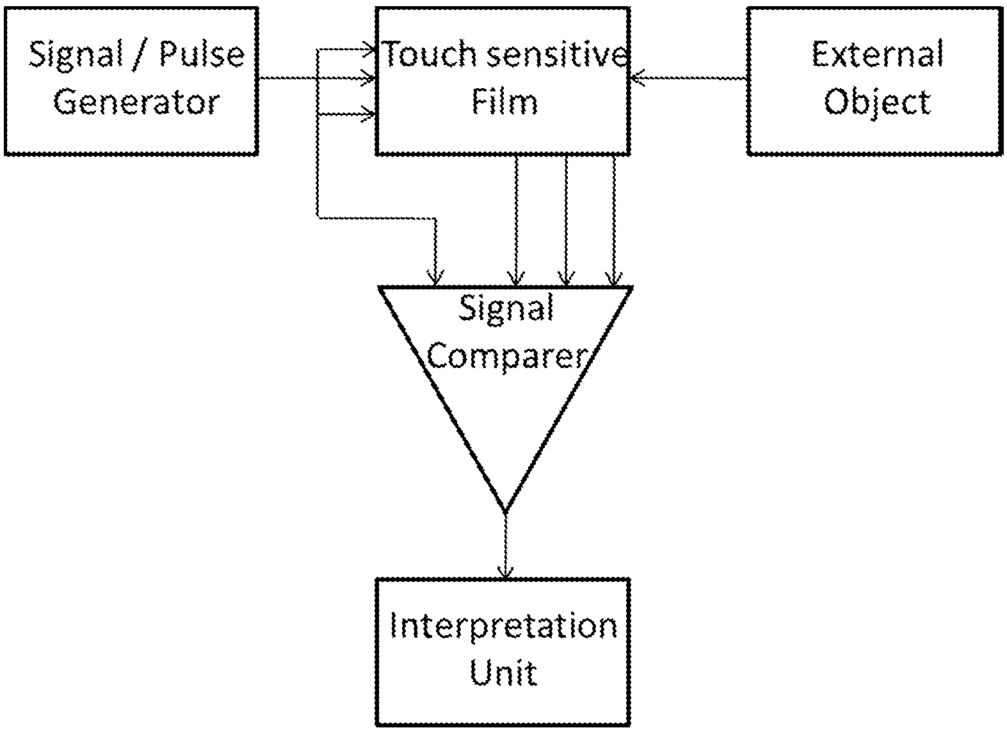


Figure 2c

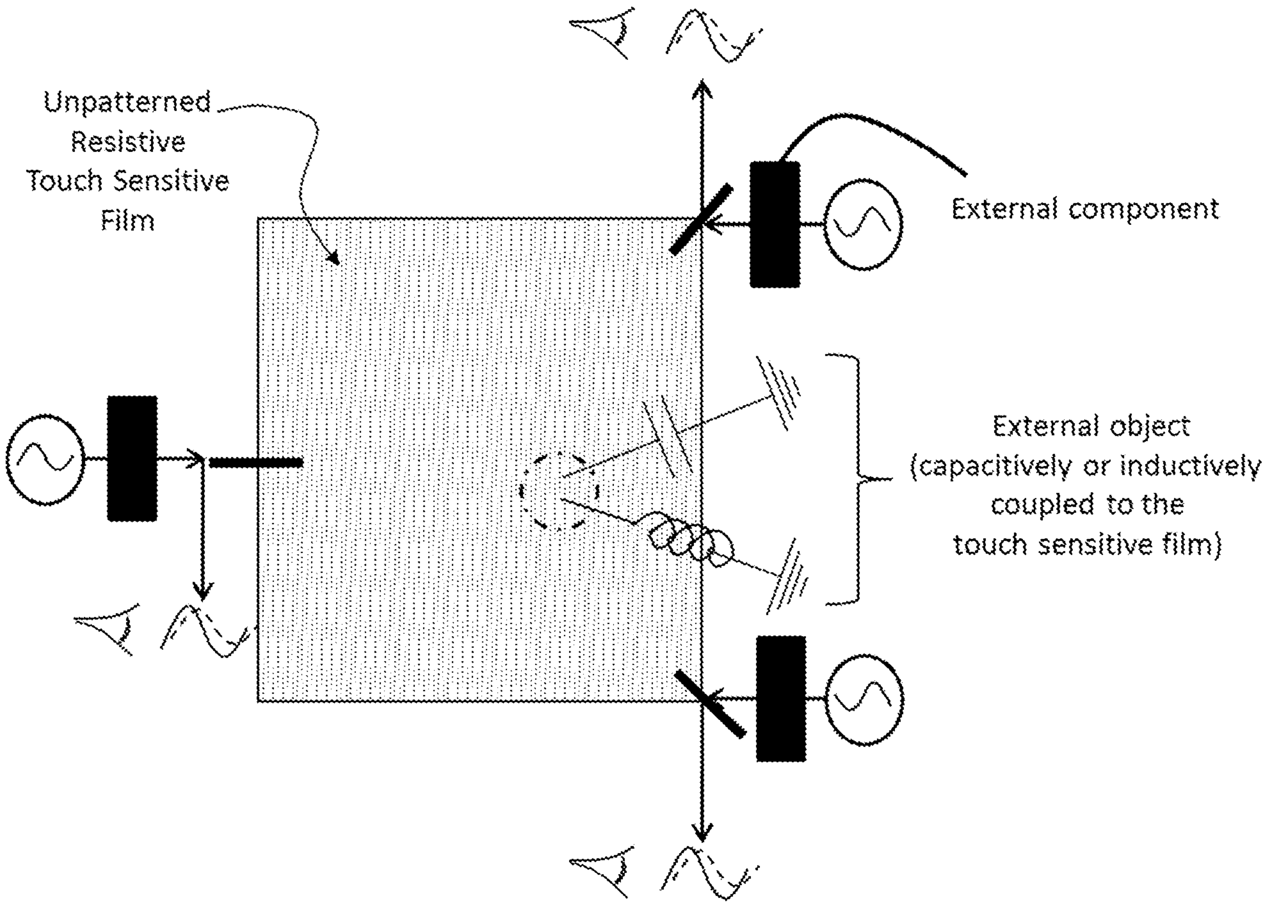

Unpatterned
Resistive
Touch Sensitive
Film
External component
External object
(capacitively or inductively
coupled to the
touch sensitive film)

Figure 3a

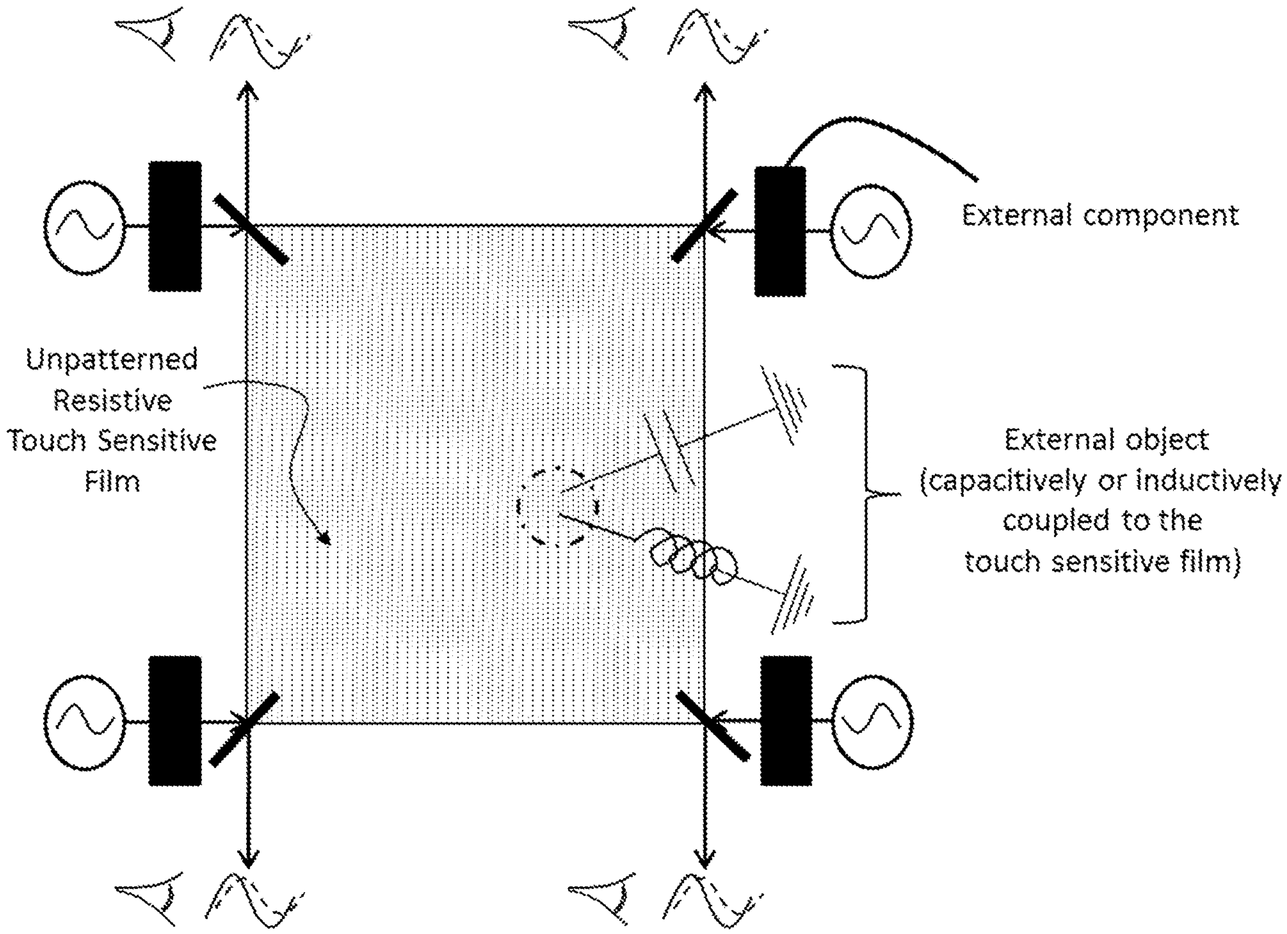

External component
Unpatterned
Resistive
Touch Sensitive
Film
External object
(capacitively or inductively
coupled to the
touch sensitive film)

Figure 3b

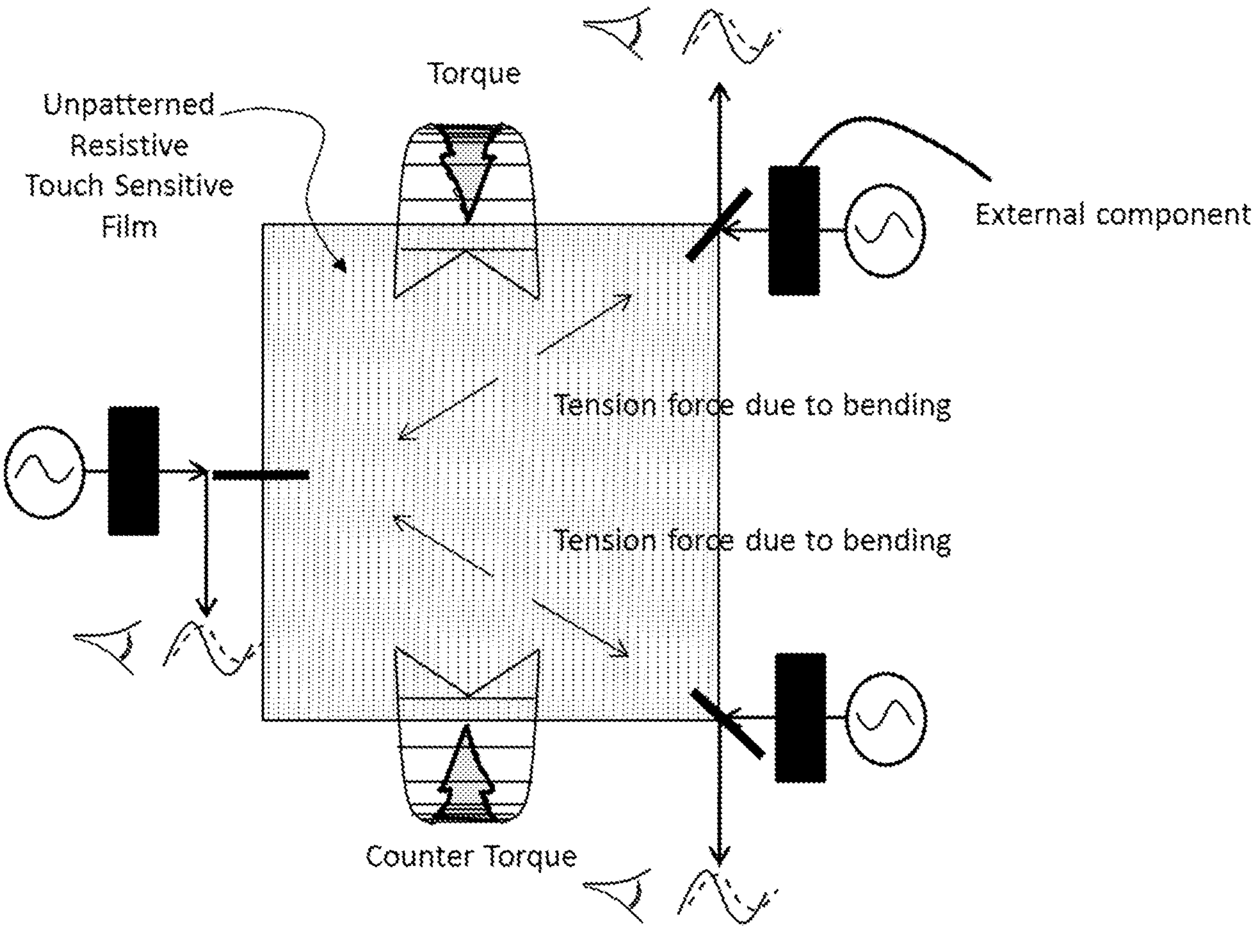
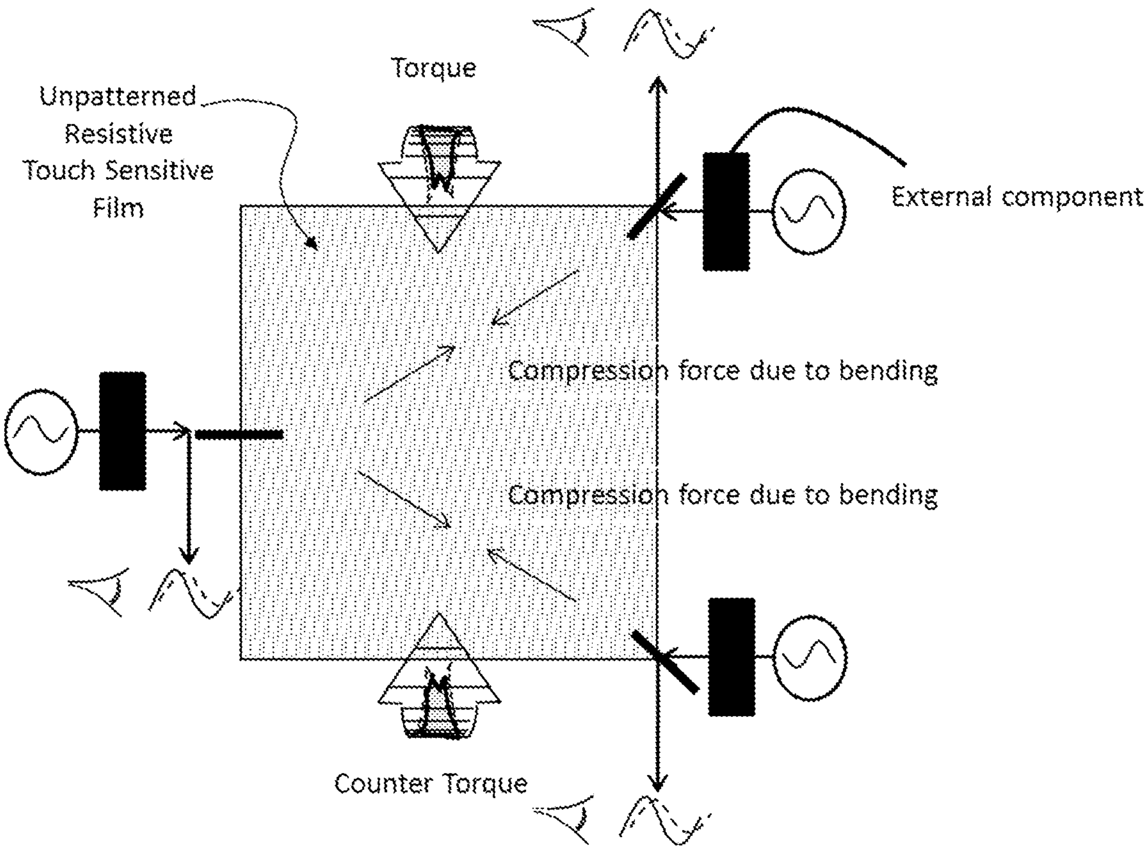

Torque
Unpatterned
Resistive
Touch Sensitive
Film
External component
Tension force due to bending
Tension force due to bending
Counter Torque

Figure 4a



Torque
Unpatterned
Resistive
Touch Sensitive
Film
External component
Compression force due to bending
Compression force due to bending
Counter Torque

Figure 4b

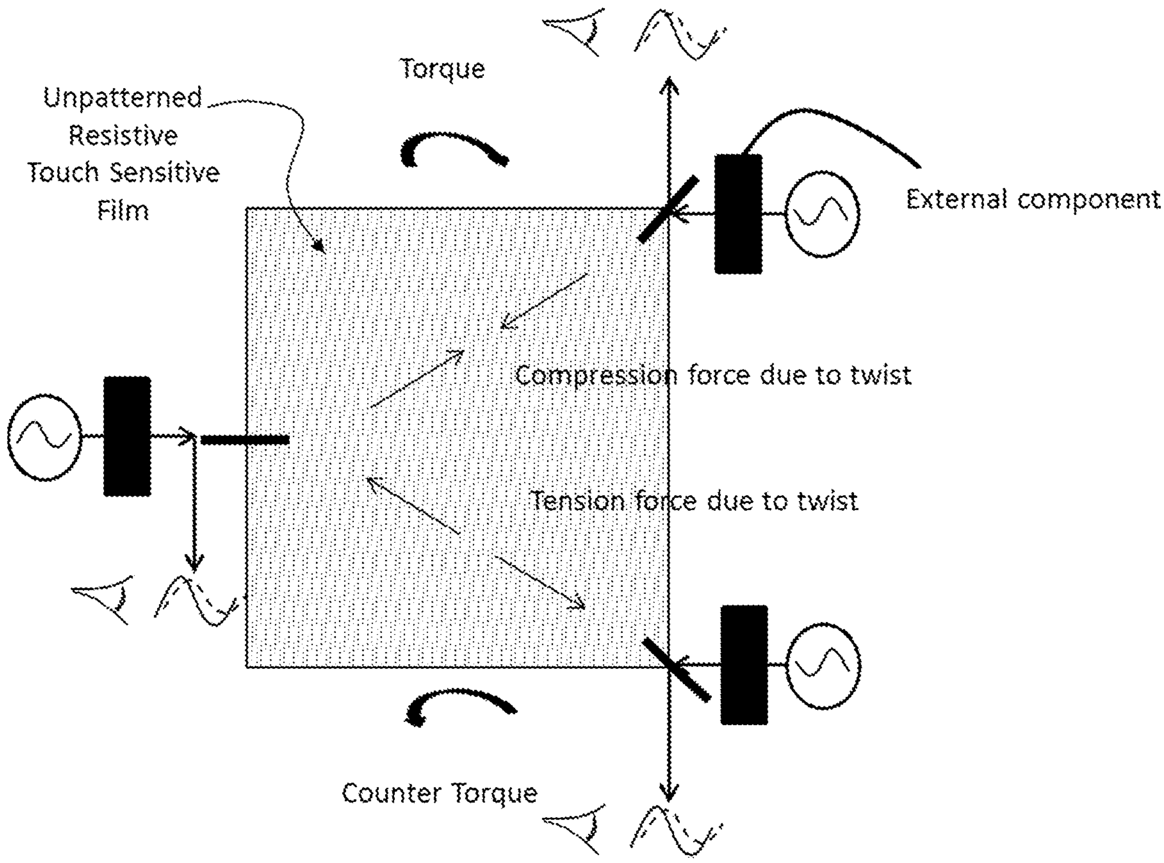

Torque
Unpatterned
Resistive
Touch Sensitive
Film
External component
Compression force due to twist
Tension force due to twist
Counter Torque

Figure 4c

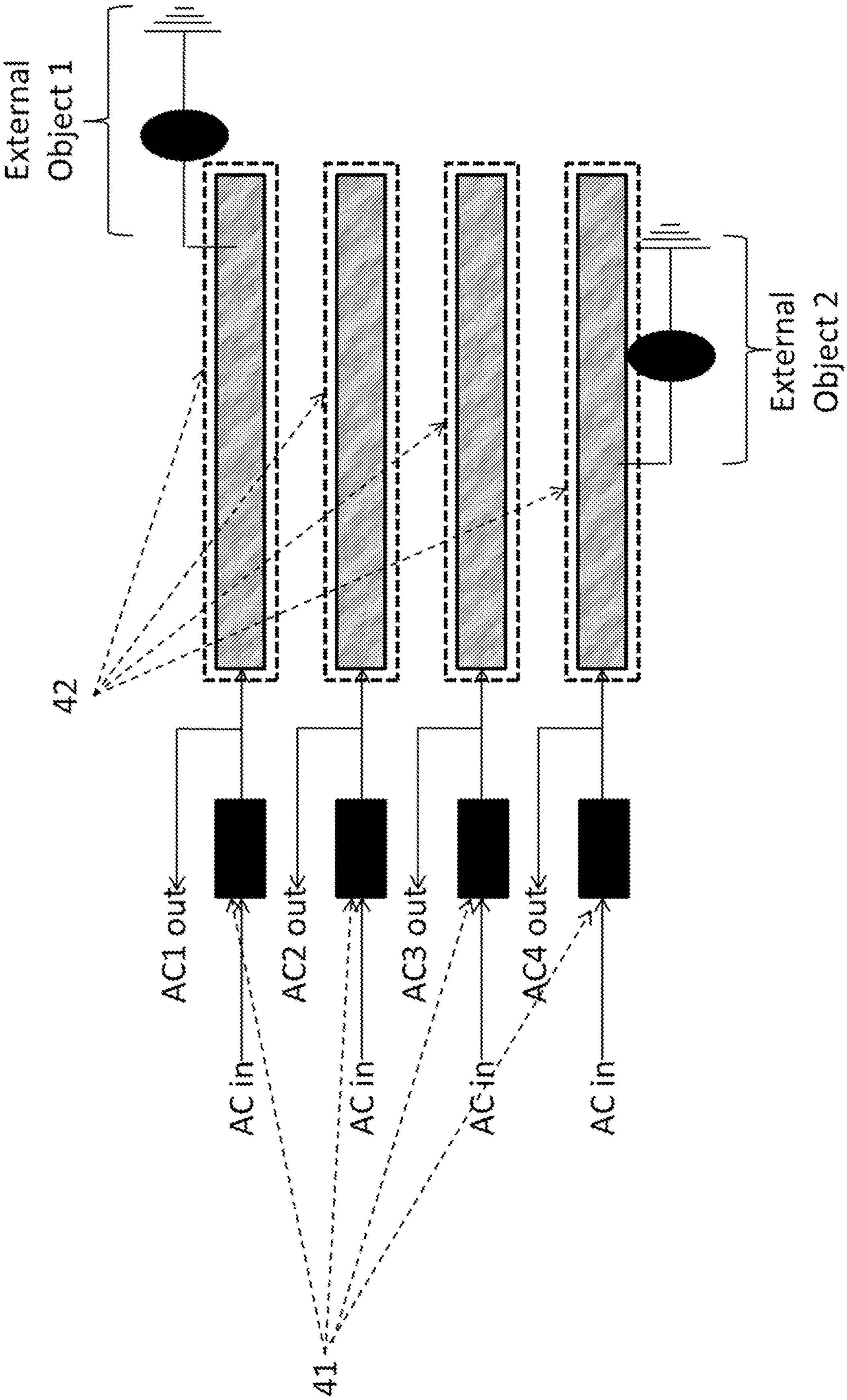

External Object 1
External Object 2
42
41
AC1 out
AC2 out
AC3 out
AC4 out
AC in
AC in
AC in
AC in

Figure 5

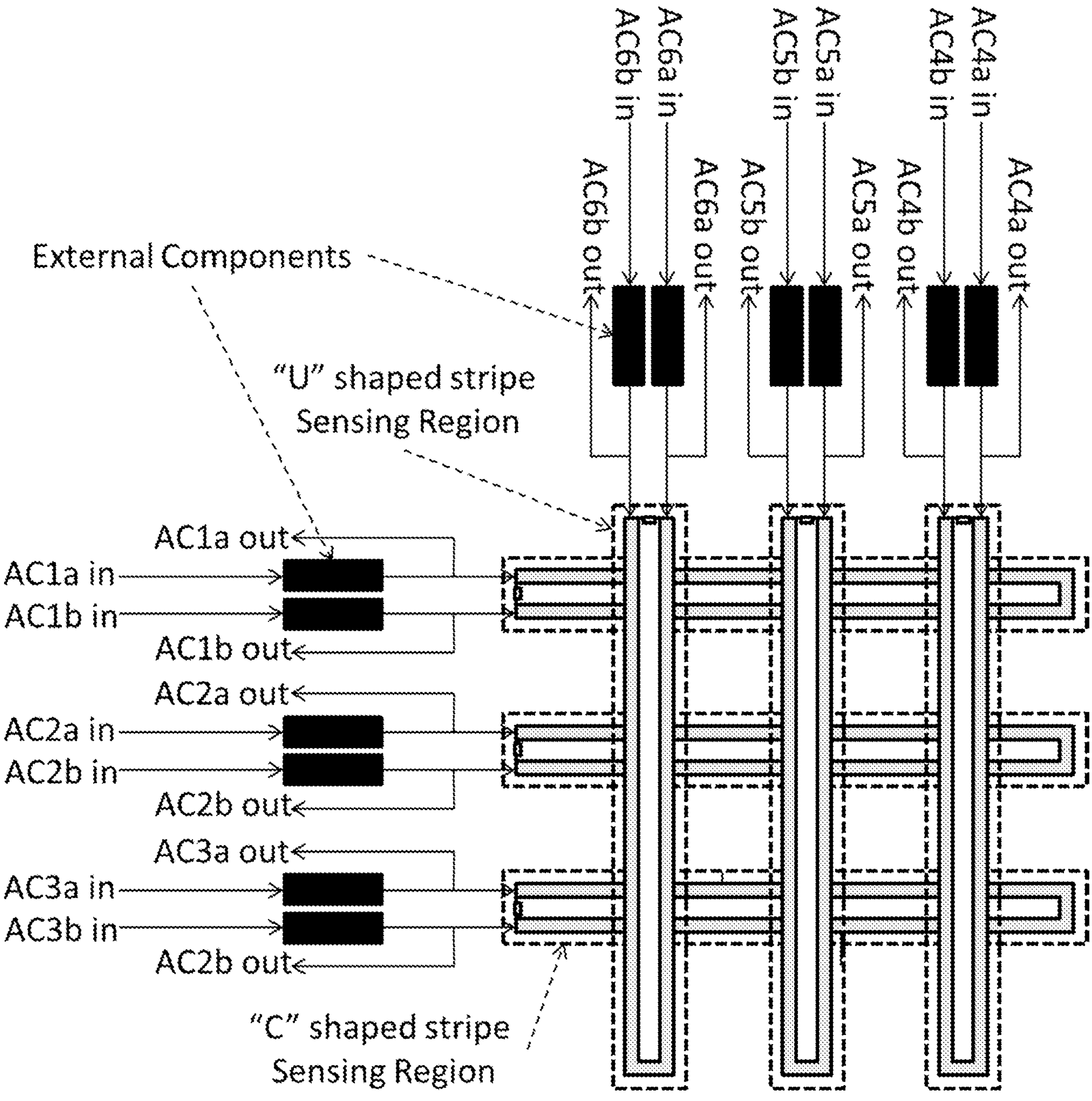

AC6b in
AC6a in
AC5b in
AC5a in
AC4b in
AC4a in
AC6b out
AC6a out
AC5b out
AC5a out
AC4b out
AC4a out
External Components
"U" shaped stripe Sensing Region
AC1a out
AC1a in
AC1b in
AC1b out
AC2a out
AC2a in
AC2b in
AC2b out
AC3a out
AC3a in
AC3b in
AC2b out
"C" shaped stripe Sensing Region

Figure 6

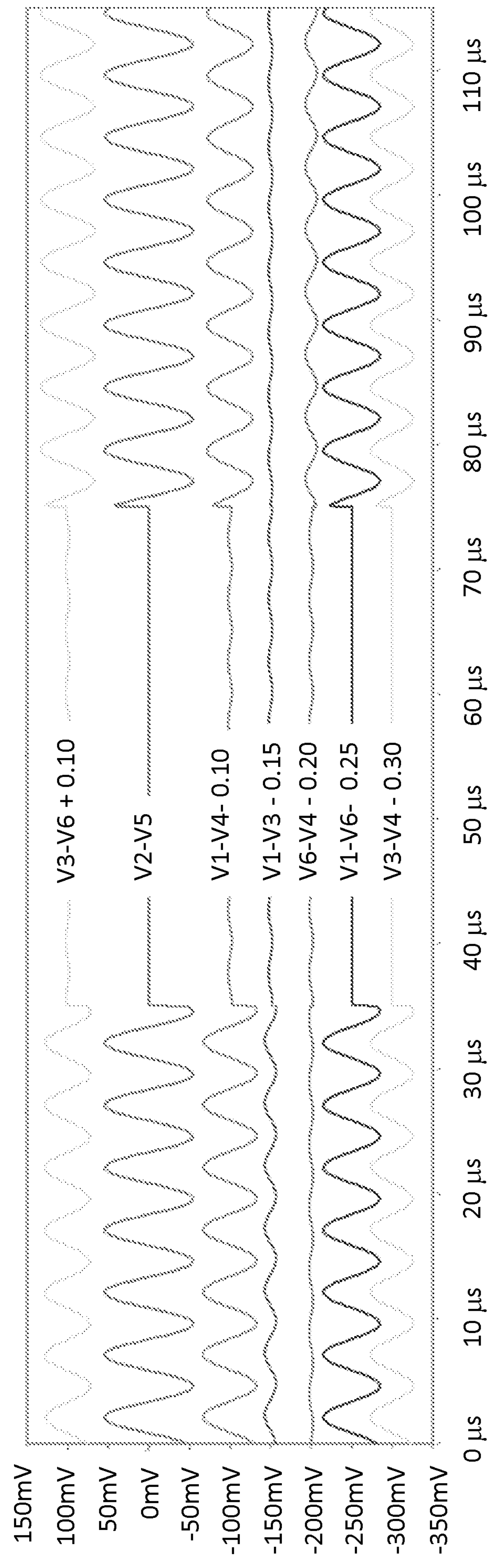

150mV
100mV
50mV
0mV
-50mV
-100mV
-150mV
-200mV
-250mV
-300mV
-350mV
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs
V3-V6 + 0.10
V2-V5
V1-V4- 0.10
V1-V3 - 0.15
V6-V4 - 0.20
V1-V6- 0.25
V3-V4 - 0.30

Figure 7a

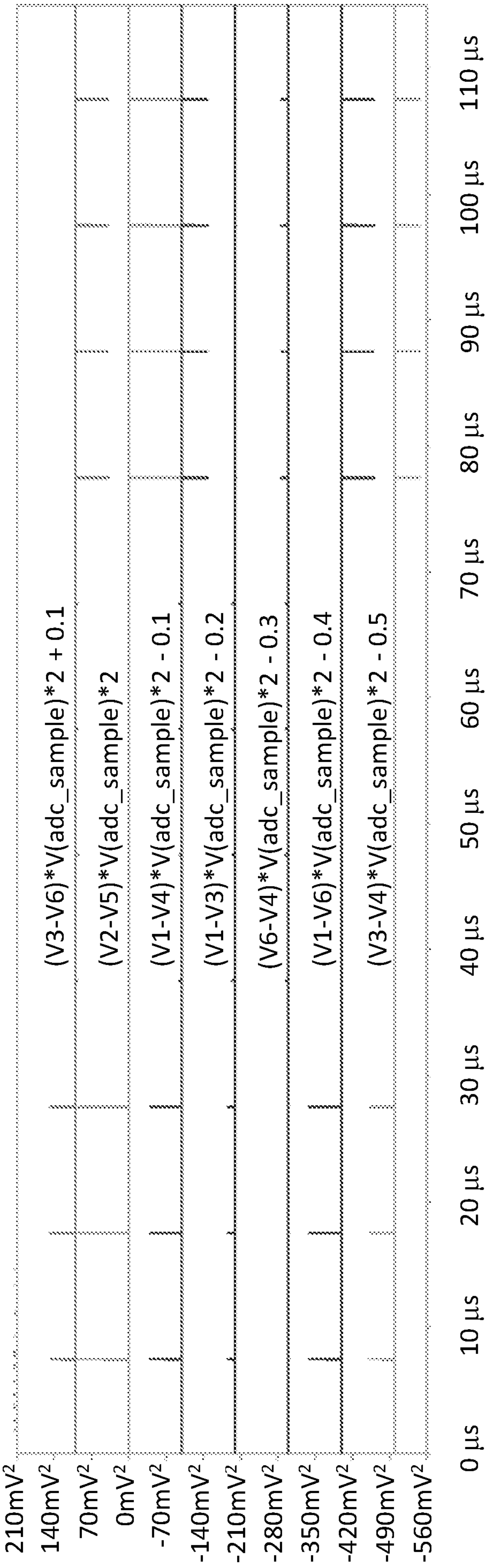

(V3-V6)*V(adc_sample)*2 + 0.1
(V2-V5)*V(adc_sample)*2
(V1-V4)*V(adc_sample)*2 - 0.1
(V1-V3)*V(adc_sample)*2 - 0.2
(V6-V4)*V(adc_sample)*2 - 0.3
(V1-V6)*V(adc_sample)*2 - 0.4
(V3-V4)*V(adc_sample)*2 - 0.5
210mV²
140mV²
70mV²
0mV²
-70mV²
-140mV²
-210mV²
-280mV²
-350mV²
-420mV²
-490mV²
-560mV²
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

Figure 7b

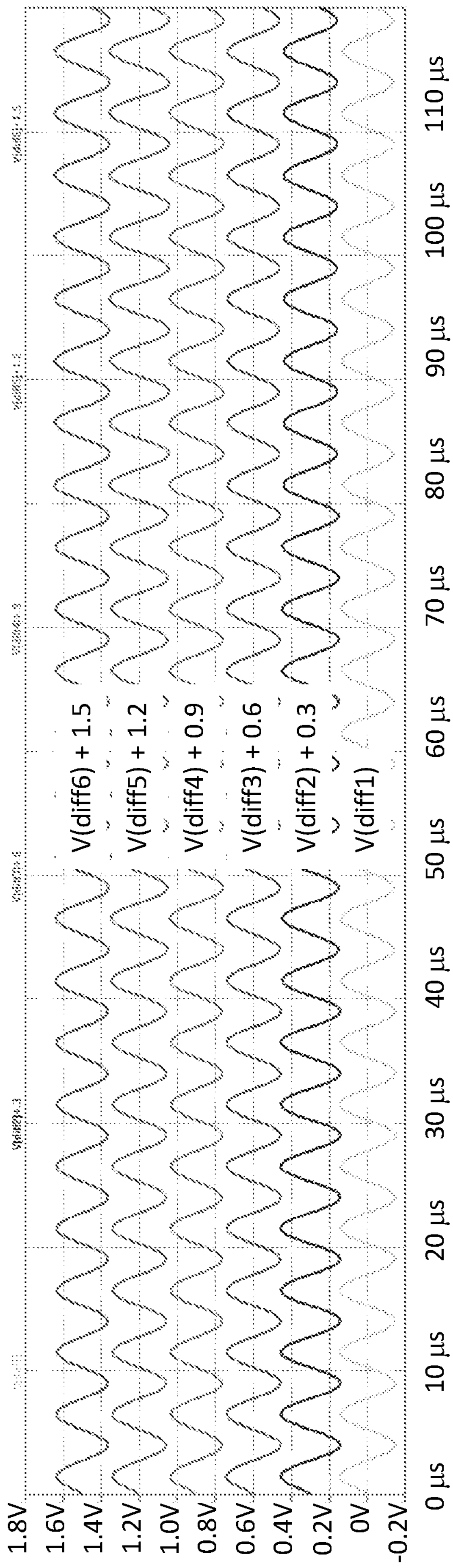

1.8V
1.6V
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0V
-0.2V
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs
V(diff6) + 1.5
V(diff5) + 1.2
V(diff4) + 0.9
V(diff3) + 0.6
V(diff2) + 0.3
V(diff1)

Figure 8a

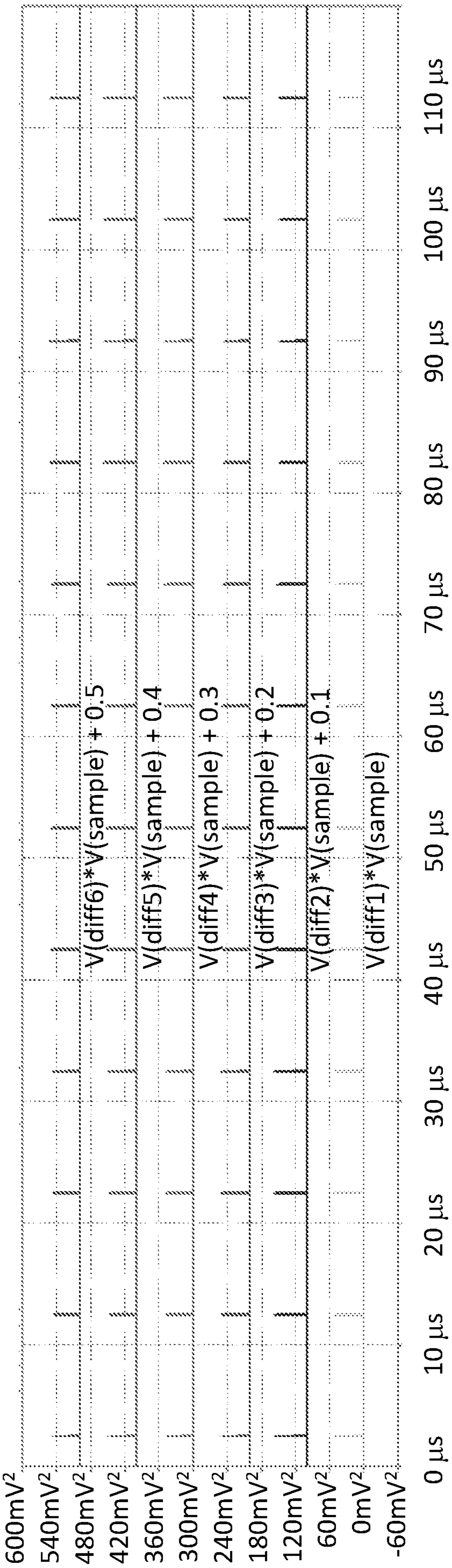
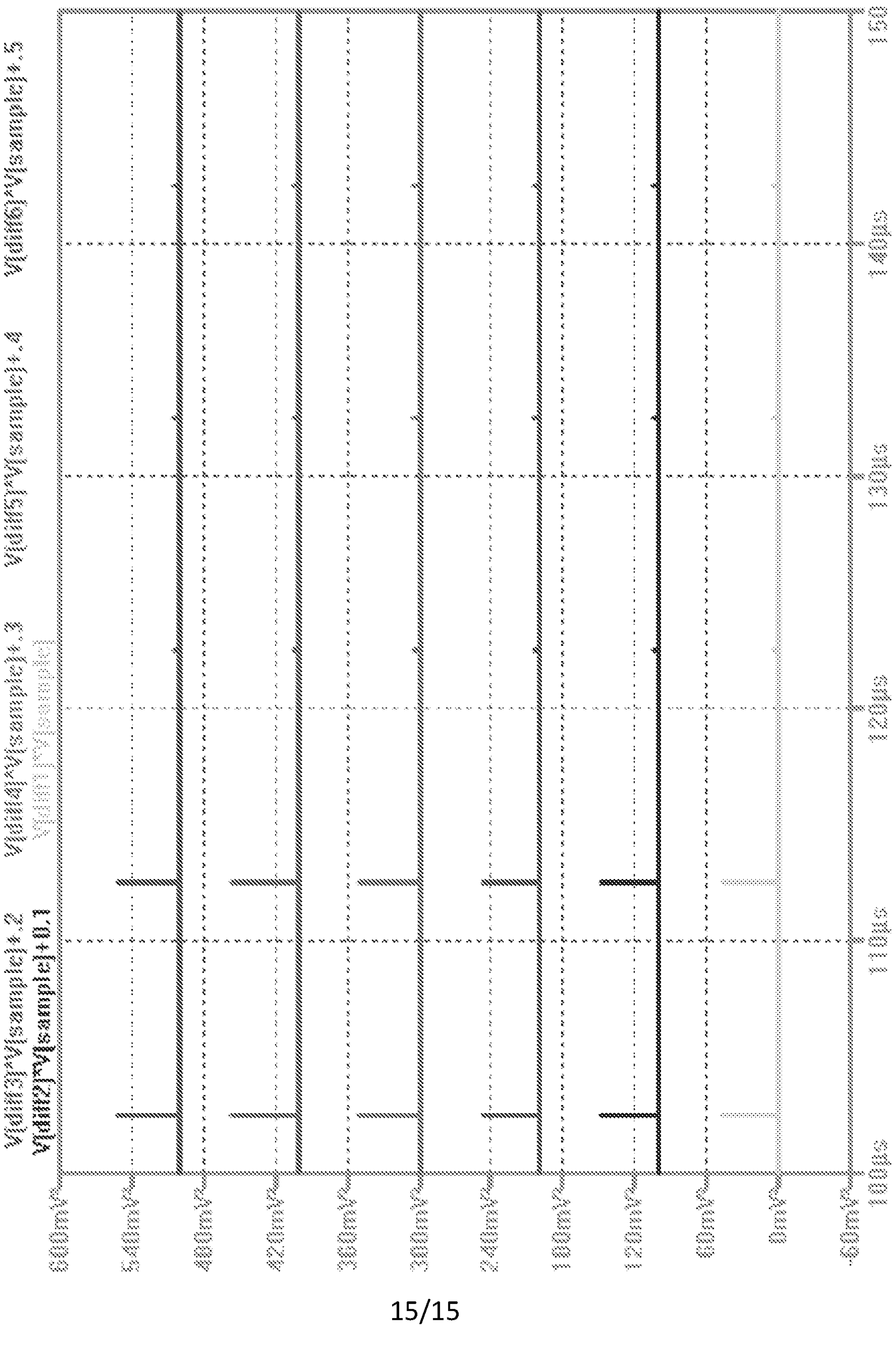

V(diff6)*V(sample) + 0.5
V(diff5)*V(sample) + 0.4
V(diff4)*V(sample) + 0.3
V(diff3)*V(sample) + 0.2
V(diff2)*V(sample) + 0.1
V(diff1)*V(sample)
600mV²
540mV²
480mV²
420mV²
360mV²
300mV²
240mV²
180mV²
120mV²
60mV²
0mV²
-60mV²
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

Figure 8b

Figure 8c


V(diff3)*V(sample)+.2
V(diff2)*V(sample)+0.1
V(diff4)*V(sample)+.3
V(diff1)*V(sample)
V(diff5)*V(sample)+.4
V(diff6)*V(sample)+.5
600mV
540mV
480mV
420mV
360mV
300mV
240mV
180mV
120mV
60mV
0mV
-60mV
100µs
110µs
120µs
130µs
140µs
150µs

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050129

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011107666 A1 (CANATU OY [FI]) 09 September 2011 (09.09.2011) the whole document, especially, page 6, line 29 – page 7, line 31; page 12, line 24 – page 13, line 17; page 14, line 8 –page 15, line 2; page 16, lines 13-26; page 14, line 24 – page 15, line 21; page 18, lines 12-17; page 22, line 23 – page 23, line 35; page 32, line 7 – page 35, line 24; page 36, line 13 – page 37, line 24; claim 9; Fig. 5	1-10, 12-20
Y		11
X	US 2011210939 A1 (REYNOLDS JOSEPH KURTH [US] et al.) 01 September 2011 (01.09.2011) the whole document, especially, paragraphs [0029]-[0031], [0035], [0038], [0041], [0047]-[0049],[0055], [0060]-[0065], [0071], [0072], [0078], [0081], [0097], [0135], [0136]; claim 12; Figs. 1A-B, 2	1-20
Y	paragraphs [0035], [0038], [0047]-[0049]; [0078]; claim 12; Fig. 1B	11

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 June 2013 (07.06.2013)	14 June 2013 (14.06.2013)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Heidi Niemi

Telephone No. +358 9 6939 500

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011141052 A1 (BERNSTEIN JEFFREY TRAER [US] et al.) 16 June 2011 (16.06.2011) the whole document, especially, paragraphs [0053], [0063],[0064], 0066], [0072], [0077], [0084], [0097], [0108]-[0116], [0124], [0134], [0143]-[0149]	1-20
X	US 2009277696 A1 (REYNOLDS JOSEPH K [US] et al.) 12 November 2009 (12.11.2009) the whole document	1, 20
X	US 2010267421 A1 (ROFOUGARAN AHMADREZA REZA [US]) 21 October 2010 (21.10.2010) the whole document	1, 20

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
WO 2011107666 A1	09/09/2011	CN 102884495 A	16/01/2013
		CN 102893369 A	23/01/2013
		EP 2542952 A1	09/01/2013
		EP 2543061 A1	09/01/2013
		FI 20105216 A	06/09/2011
		TW 201200468 A	01/01/2012
		TW 201203041 A	16/01/2012
		US 2012327004 A1	27/12/2012
		US 2013050113 A1	28/02/2013
		WO 2011107665 A1	09/09/2011
US 2011210939 A1	01/09/2011	CN 102884496 A	16/01/2013
		EP 2539798 A2	02/01/2013
		KR 20130009957 A	24/01/2013
		US 2011210940 A1	01/09/2011
		US 2011210941 A1	01/09/2011
		WO 2011106575 A2	01/09/2011
US 2011141052 A1	16/06/2011	AU 2010328407 A1	26/07/2012
		AU 2012101005 B4	21/03/2013
		CN 102713805 A	03/10/2012
		DE 112010004756 T5	14/03/2013
		EP 2510423 A2	17/10/2012
		KR 20120103670 A	19/09/2012
		MX 2012006710 A	30/07/2012
		TW 201135567 A	16/10/2011
		WO 2011071837 A2	16/06/2011
US 2009277696 A1	12/11/2009	WO 2009137155 A1	12/11/2009
US 2010267421 A1	21/10/2010	None	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050129

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
G06F 3/044 (2006.01)

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 104169851 A

(43)申请公布日 2014.11.26

(21)申请号 201380015146.7

(22)申请日 2013.02.06

(30)优先权数据

61/595,309 2012.02.06 US

(85)PCT国际申请进入国家阶段日

2014.09.19

(86)PCT国际申请的申请数据

PCT/FI2013/050129 2013.02.06

(87)PCT国际申请的公布数据

WO2013/117815 EN 2013.08.15

(71)申请人 卡纳图有限公司

地址 芬兰赫尔辛基

(72)发明人 马蒂·汉努·鲁苏宁 简·凡普法勒 比约恩·弗里厄尔·米克拉达尔 布拉德利·J·艾奇逊 大卫·P·布朗

(74)专利代理机构 北京安信方达知识产权代理有限公司 11262

代理人 孙静 王漪

(51)Int.Cl.

G06F 3/044(2006.01)

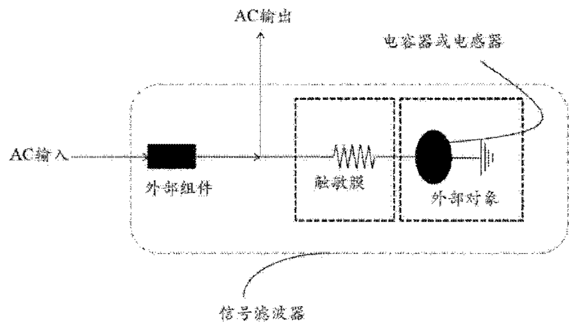
权利要求书2页 说明书12页 附图15页

(54)发明名称

触摸感测设备及检测方法

(57)摘要

一种触摸感测设备,包括:一个触敏膜、一个信号滤波器、电气电路和一个处理单元。根据本发明,当一个外部对象进行触摸时,该膜能够电容或电感耦合到所述对象。该信号滤波器至少由该膜的该电阻和到该外部对象的该电容或电感耦合形成,并且该滤波器具有至少受该触摸的位置和/或该触摸的电容或电感影响的特性。该电气电路在一个或多个位置处耦合到该触敏膜,并且被配置成用于提供一个或多个具有至少一个频率、振幅和波形的激励信号到该信号滤波器以及从该信号滤波器接收一个或多个响应信号。该处理单元耦合到该电气电路并且被配置成用于通过处理一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的触摸的存在或接近度、所述触摸的位置、所述触摸的电容和/或电感。



CN 104169851 A

1. 一种触摸感测设备,包括 :

- 一个触敏膜,该触敏膜包括具有一个电阻的导电材料,当一个外部对象进行一次触摸时,该膜能够电容或电感耦合到所述外部对象,

- 一个信号滤波器,该信号滤波器至少由该触敏膜的该电阻和到该外部对象的该电容或电感耦合形成,该滤波器具有至少受该触摸的位置、该触摸的电容或电感或者受该触摸的所述特性的组合影响的特性,

- 电气电路,该电气电路在一个或多个位置处电阻地或者无线地耦合到该触敏膜,该电气电路被配置成用于提供一个或多个具有至少一个频率、振幅和波形的激励信号到该信号滤波器并且从该信号滤波器接收一个或多个响应信号,以及

- 一个处理单元,该处理单元电阻地或者无线地耦合到该电气电路,其中,该处理单元被配置成用于通过处理一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的一次触摸的存在或接近度、所述触摸的位置、所述触摸的电容或电感、或者其组合。

2. 根据权利要求 1 所述的触摸感测设备,其中,该信号滤波器是一个低通滤波器。

3. 根据权利要求 1 或 2 任一项所述的触摸感测设备,其中,该电气电路被配置成用于从该信号滤波器接收至少两个响应信号 ;并且其中,该处理单元被配置成用于通过将所述响应信号相互比较并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的一次触摸的存在、所述触摸的位置、所述触摸的电容或电感、或者其组合。

4. 根据权利要求 1 或 2 任一项所述的触摸感测设备,其中,该电气电路被配置成用于从该信号滤波器接收至少一个响应信号 ;并且其中,该处理单元被配置成用于通过将所述响应信号与源信号进行比较并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的一次触摸的存在、所述触摸的位置、所述触摸的电容或电感、或者其组合。

5. 根据权利要求 1 至 4 任一项所述的触摸感测设备,进一步包括一个经由该电气电路电阻地或无线地耦合到该处理单元的外部组件,其中,该信号滤波器进一步由所述至少一个外部组件形成。

6. 根据权利要求 1 至 5 任一项所述的触摸感测设备,其中,该信号滤波器的特性进一步受所述外部对象和该感测膜之间的距离、该外部对象的电容或电感、所述外部对象的物理特性、该膜的该电阻、在该敏感膜材料和该外部对象之间的一个电介质或绝缘层的存在、厚度或介电常数、或者其组合的影响。

7. 根据权利要求 1 至 6 任一项所述的触摸感测设备,其中,该电气电路包括一个或多个电极,并且其中,这些电极中的至少一个被配置成用于将所述激励信号提供到该信号滤波器,并且这些电极中的至少一个被配置成用于从该信号滤波器接收所述电响应信号。

8. 根据权利要求 1 至 7 任一项所述的触摸感测设备,其中,该信号滤波器的特性包括振幅响应、相位响应、电压响应、电流响应、信号形状响应或者其组合。

9. 根据权利要求 8 所述的触摸感测设备,其中,该处理单元进一步被配置成用于基于该激励信号的至少一个预先确定的频率、振幅和波形来选择一个或多个有待测量的特性。

10. 根据权利要求 1 至 9 任一项所述的触摸感测设备,其中,该触敏膜作为一个连续结构在一个平面内延伸。

11. 根据权利要求 1 至 9 任一项所述的触摸感测设备,其中,该触敏膜包括 :

两个或更多个平行的条带，这些条带由该导电材料制成并且在该触敏膜上向一个方向延伸，以及

在所述条带之间的多个区域，这些区域包括非导电材料，

其中，该电气电路电阻地或者无线地耦合到这些条带的每一个，并且该处理单元进一步被配置成用于沿着每个条带检测该触摸的存在和位置。

12. 根据权利要求 1 至 11 任一项所述的触摸感测设备，其中，该触敏膜被形成为一个柔性结构，以便允许该触敏膜弯曲。

13. 根据权利要求 1 至 11 任一项所述的触摸感测设备，其中，该触敏膜被形成为一个可变形结构，以便允许该触敏膜变形从而形成一个三维表面。

14. 根据权利要求 1 至 13 任一项所述的触摸感测设备，其中，该触敏膜是光学透明的。

15. 根据权利要求 1 至 14 任一项所述的触摸感测设备，其中，该触敏膜包括一个高纵横比分子结构 (HARMS) 网络、一种导电聚合物、石墨烯或一种陶瓷或者金属氧化物。

16. 根据权利要求 1 至 15 任一项所述的触摸感测设备，其中，该触敏膜同样用作一种触觉界面膜。

17. 根据权利要求 1 至 16 任一项所述的触摸感测设备，其中，该触敏膜同样用作一种变形检测膜。

18. 根据权利要求 1 至 17 任一项所述的触摸感测设备，其中，由该处理单元确定的该电容或电感被用作一个用于确定力或者该触摸的力的相对变化的代理。

19. 根据权利要求 1 至 17 任一项所述的触摸感测设备，其中，所述设备的部件之间的无线耦合是下列情形之一：通过无线电波耦合、通过磁场耦合、电感或电容耦合。

20. 一种用于用触摸感测设备确定外部对象的存在、接近度、位置、电感、电容或者这些特征的组合的方法，该方法包括：

- 提供一个或多个具有至少一个频率、振幅和波形的电激励信号到一个信号滤波器，该信号滤波器至少由在该触摸感测设备中的一个触敏膜的一个电阻和所述膜与该外部对象的一个电容或电感耦合形成，

- 从该信号滤波器接收一个或多个响应信号，以及

- 通过处理所述一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的一次触摸的存在、或者所述触摸的位置。

触摸感测设备及检测方法

发明领域

[0001] 本发明涉及触摸感测设备，更具体地，涉及具有触敏膜的触摸感测设备以及一种检测触摸并检测其位置的方法。

[0002] 发明背景

[0003] 现今，用于不同种类的电装置的用户接口越来越经常地用基于触敏膜而不是常规的机械按钮的不同类型的触摸感测设备来制作。众所周知的示例包括移动电话、便携式计算机和类似设备中的不同种类的触摸板和触摸屏。除了可实现高级的乃至奢侈的用户体验以外，基于触敏膜的触摸感测设备还为不断努力寻找功能上更通用、更小、更便宜、更轻以及在视觉上也更有吸引力的设备的设计者提供较多的自由。

[0004] 这类触摸感测设备中的关键元件是触敏膜，该触敏膜包括被配置成用作一个或多个感测电极的一个或多个导电层。这种膜的一般操作原理是借助于该触敏膜所连接到其上的测量电路检测到用户通过例如指尖或某种特定的指示器设备的触摸。实际的测量原理可以是例如电阻式的或电容式的，现今后者通常被认为是在最苛刻的应用中提供最佳性能的最先进的替代方案。

[0005] 电容触摸感测是基于在触敏膜上的触摸，从电的观点，指的是将外部电容耦合到触敏膜所连接到其上的测量电路这一原理。对于具有足够高灵敏度的触敏膜，甚至不需要直接接触该触敏膜，而只通过将一个合适的对象接近该触敏膜就可以实现电容耦合。在测量电路的信号中检测到电容耦合。在一种所谓的投射电容方法中，测量电路包括分别用于提供信号和感测电容耦合的驱动电极和感测电极。这一电路也被安排成用于顺序地快速地扫描感测电极，这样使得测量每个供电 / 测量电极对之间的耦合。

[0006] 对于投射电容方法中已知的触敏膜，常见的是正确地确定触摸的位置必然需要在导电层中的大量的分离感测电极。换言之，导电层被图案化成分离感测电极的网络。希望得到的分辨率越精确，需要的感测电极配置就越复杂。一个尤其具有挑战性的问题是多个同时触摸的检测，从另一个方面来说，该检测常常是触摸感测设备目前发展水平最希望得到的特性之一。复杂的感测电极配置和大量的单个感测电极元件使得触摸感测设备的制造工艺以及测量电子设备复杂化。

[0007] 在触摸屏中，除了触摸感测能力之外，触敏膜必须是光学透明的，从而使得该膜能够在电子设备的显示器中或其顶部使用，即，使得能够通过触敏膜看到设备的显示器。此外，从触敏膜可见性的观点，透明性也是非常重要的。触敏膜的可见性对于例如 LCD（液晶显示器）、OLED（有机发光二极管）显示器、或电子纸 (e-paper) 显示器的用户来说，严重地恶化了用户体验。到目前为止，透明的导电氧化物如铟锡氧化物 (ITO) 已经形成了触敏膜中最常见的一组导电层材料。然而，从可见性的观点，它们远非一个理想的解决方案。例如 ITO 的高折射率使得图案化的感测电极可见。强调这个问题是因为感测电极图案化变得更加复杂化。

[0008] 在由网络化的纳米结构形成的或包括这些网络化的纳米结构的层中发现了一种在触敏膜中的有希望的新方法。除了合适的导电性能以外，由例如碳纳米管 (CNT) 的网

络或具有共价地键合到管状碳分子的一侧的富勒烯或类富勒烯分子的碳 NANOBUD 的网络（NANOBUD® 是卡娜图沃伊 (Canatu Oy) 的注册商标）组成的层可以制成比例如透明的导电氧化物（如 ITO、ATO 或 FTO) 对于人眼来说更不可见。此外，如众所周知的，与例如透明的导电氧化物相比，基于纳米结构的层可以拥有更优越的柔性、机械强度以及稳定性。

[0009]　在 US 2009/0085894 A1 中报告了一个基于纳米结构的解决方案。根据其描述，纳米结构可以是例如不同类型的碳纳米管、石墨烯片或纳米线。所提及的膜的掺杂作为用于增加其导电性的手段。在此讨论了基于互电容和单层自电容方法的双层配置。借助于所披露的膜，声明多触摸检测是可能的。然而，这个文件中没有解决非常复杂的电极和测量电路配置的常见问题。

[0010]　WO 2011/107666 A1 中建议了另一个现有技术解决方案。其披露了一个具有例如由纳米结构网络制成的触敏膜的触摸感测设备，该膜具有大于 3.0kΩ 的薄层电阻。当在本发明中着手解决复杂的电路的问题时，仍然只建议用高电阻膜并且在有限的频率范围内操作。

[0011]　需要提供通用的触摸感测设备，该通用的触摸感测设备具有简单的感测电极配置、优选地使能单层电容工作原理、能够在大范围导电膜电阻上操作、使能信号频率调谐用于更好的噪声控制、并且允许使用多种多样的感测算法。

[0012]　发明目的

[0013]　本发明的目的是提供新颖的解决方案，这些解决方案至少具有上述优点的一部分或者全部。

[0014]　发明概述

[0015]　根据本发明的第一个方面，提供了一种触摸感测设备，包括：一个触敏膜，该触敏膜包括具有一个电阻的导电材料，当一个外部对象进行触摸时，该膜能够电容或电感耦合到所述外部对象；一个信号滤波器，该信号滤波器至少由该触敏膜的该电阻和到该外部对象的该电容或电感耦合形成，该信号滤波器具有至少受该触摸的位置、该触摸的电容或电感或者受该触摸的所述特性的组合影响的特性；电气电路，该电气电路在一个或多个位置处电阻地或者无线地耦合到该触敏膜，该电气电路被配置成用于提供一个或多个具有至少一个频率的激励信号到该信号滤波器并且从该信号滤波器接收一个或多个响应信号；以及一个处理单元，该处理单元电阻地或者无线地耦合到该电气电路，其中，该处理单元被配置成用于通过处理一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的触摸的存在或接近度、所述触摸的位置、所述触摸的电容或电感、或者其组合。

[0016]　一般而言，触敏膜指的是可以用作触摸感测设备中的触敏元件的膜。此处，触摸感测设备被宽泛地理解成涵盖通过经由外部对象来触摸设备进行操作的所有用户接口设备，以及用于检测此类对象的存在、接近度和位置的其他类型的设备。

[0017]　本发明的触敏膜能够电容或电感耦合到外部对象，这意味着由外部对象进行的触摸在膜的滤波特性中引起变化。

[0018]　在本发明的上下文中使用了单词“触摸”及其衍生词，在广义不仅涵盖了在指尖、触笔、或某些其他指示器或对象和触敏膜之间的直接的机械或物理接触，并且也涵盖了如下情形：这种对象位于触敏膜的附近，这样使得该对象在触敏膜和周围环境之间或者在触

敏膜的不同点之间产生足够的电容或电感耦合。在这个意义上，本发明的触敏膜也能够被用作接近度传感器。

[0019] 所谓“导电材料”此处指的是能够允许电荷在材料中流动的任何材料，而不考虑该材料的导电机制或导电类型。因此，导电材料此处还涵盖例如半导电或半导体材料。在触敏膜中可能有一层或多层导电材料。

[0020] 除了导电材料以外，触摸感测设备还可以包括实施整个工作触敏元件所需的其他材料层和结构。例如，可以存在用于该膜的机械保护的一个或多个层。此外，还可以存在用于折射率或颜色匹配的一个或多个层和 / 或例如用于抗刮擦、装饰、防水、自清洁或其他目的的一个或多个涂层。除了分层的元件之外，触敏膜还可以包括三维组织的结构，例如贯穿触敏膜或其一部分延伸的接触结构。

[0021] 信号滤波器至少由触敏膜电阻和到外部对象的电容或电感耦合形成。该信号滤波器可以是例如低通滤波器、高通滤波器、带阻或带通滤波器。低通滤波器的示例将是跨输入的 RC（电阻器 - 电容器）串联电路，其中，跨电容器取得输出。在本发明的示例性实施例中，在上述低通滤波器中，膜电阻可以表示 R 以及由触摸创建的电容耦合可以表示 C。

[0022] 所谓“外部对象”指的是任何电容器或电感器或者电容或电感指示器（例如人的手指或金属触笔）、具有电容元件或用于电感耦合的金属线圈的指示器等。例如，具有线圈的触笔既可以是无源的（没有将电流主动地施加于该线圈）也可以是有源的（将 AC 或 DC 电流施加于该线圈）。通常使用具有有源线圈的触笔来提高触摸的准确度、响应时间、或透明性。

[0023] 通过触敏膜的电阻和到外部对象的耦合形成信号滤波器是基于发明人的观察，即，响应于来自外部对象的触摸，这种滤波器改变其特性，以及可以测量这一改变从而检测触摸、其位置并且用非常高的精度确定触摸的电容或电感。

[0024] 在一个或多个位置将根据本实施例的电气电路电阻地或者无线地耦合到触敏膜。该电路可以包括不同类型的接触电极、线路和其他形式的导体、开关、以及将触敏膜及其一个或多个导电层连接到触摸感测设备的剩余部分所需的其他元件。电阻连接暗指物理接触，而例如无线电波、电感或电容耦合涉及无线耦合。电阻耦合的示例包括但不限于焊接、钳位或其他传统的技术。

[0025] 电气电路被配置成用于为信号滤波器提供一个或多个激励信号，并且从该滤波器接收一个或多个响应信号。如下文所描述的，将电气电路连接到处理单元。在本发明的一个示例性实施例中，通过处理单元经由电气电路将信号发送到滤波器并且从其接收信号。所提供的一个或多个激励信号具有至少一个频率、振幅和波形。这意味着每个信号可以在频率、振幅或波形上变化或者具有恒定的频率、振幅和波形，并且在多个信号的情况下，其可以具有相等的或不同的频率、振幅和波形。实际上，可以将电气电路连同处理单元部分地或者完全地集成到单个芯片。

[0026] 激励信号可以是任何电信号（例如脉冲的、上升下降时间受限的或振荡的电压或电流），该电信号经由电路被提供给触敏膜的信号滤波器并且提供适合于监测由触摸引起滤波器特性的变化的条件。激励信号也可以例如被称为驱动信号或刺激信号。典型的示例是 AC 电流和 / 或电压。响应信号相应地是通过使用电路从信号滤波器接收并且允许基于由触摸引起的和这个信号可检测的滤波器特性的变化来检测触摸的任何所测量的电信号。

[0027]　在一个实施例中，将处理单元电阻地或者无线地耦合到电气电路。处理单元被配置成用于通过处理一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由外部对象进行的触摸的存在或接近度、所述触摸的位置、所述触摸的电容或电感、或者其组合。

[0028]　处理单元可以包括处理器、信号或脉冲发生器、信号比较器、解释单元、和其他硬件和电子设备以及处理响应信号所必需的软件工具。

[0029]　触摸感测设备能够利用只具有一个单一导电层的触敏膜在单层模式下操作。大多数现有技术的电容触敏膜利用对于激励和响应信号使用不同的导电层的双层方法，与其相比，这是一个有利的简化。

[0030]　根据一个实施例，电气电路被配置成用于从信号滤波器接收一个或多个响应信号。在本实施例中，处理单元被配置成用于通过将所述响应信号相互比较并且由此测量信号滤波器的特性的变化来检测由外部对象进行的触摸的存在或接近度、所述触摸的位置、所述触摸的电容或电感、或者其组合。在一个替代实施例中，处理单元被配置成用于将响应信号与激励信号进行比较，从而测量信号滤波器的特性的变化。

[0031]　在一个实施例中，将交流电流或电压作为激励信号在信号滤波器的一个点处提供给信号滤波器，并且在滤波器的另一个点处测量作为响应信号的交流电压或电流。

[0032]　在一个实施例中，信号滤波器进一步由至少一个外部组件形成。该至少一个外部组件是上述实施例的触摸感测设备的一部分，并且经由电气电路将其电阻地或无线地耦合到处理单元。该外部组件可以是电阻器、恒流源、电容器或电感器或者其组合。可以将该外部组件集成到设备中的其他单元中。

[0033]　在一个实施例中，将交流电流或电压作为激励信号在信号滤波器的一个点处通过外部组件提供给信号滤波器，并且在滤波器的同一个点处测量作为响应信号的交流电压或电流。

[0034]　根据一个实施例，信号滤波器的特性进一步受所述外部对象和感测膜之间的距离、外部对象的电容或电感、所述外部对象的物理特性、膜的电阻、在敏感膜材料和外部对象之间的电介质或绝缘层的存在、厚度或介电常数、或其组合的影响。

[0035]　外部对象的物理特性包括例如其几何结构、材料、定向和配置。

[0036]　根据一个实施例，电气电路包括一个或多个电极，并且其中，这些电极中的至少一个被配置成用于将所述激励信号提供到信号滤波器，并且这些电极中的至少一个被配置成用于从信号滤波器接收所述电响应信号。这些电极的数量可以取决于结构而变化。

[0037]　在一个优选实施例中，信号滤波器的所测量的特性包括振幅响应、相位响应、电压响应、电流响应或其组合。这些特性会受触摸的存在或接近度、其位置以及其电容或电感的影响。

[0038]　根据本发明的一个优选实施例，处理单元进一步被配置成用于基于激励信号的至少一个预先确定的频率、振幅和波形来选择一个或多个有待测量的特性，从而将信噪比最大化和／或提高设备在该预先确定的频率、振幅和波形上的准确度。

[0039]　最优的激励频率取决于许多因素。在较低频率处噪声会增加。另一方面，干扰触摸检测的天线效应在甚高频下成为一个问题。天线效应指的是测量电路的不同部分起到如同天线的作用，趋向于在电路和周围环境之间耦合扰动信号。通常在下限截止频率和上限

截止频率之间有一个最优的频率范围。例如，该范围取决于在触敏膜中的导电材料的电阻、在该膜上的任何涂层的厚度和介电常数、外部对象的电容或电感、周围电子设备的频率和导电膜位于其上的衬底的材料。例如，具有一个足够的高频率，PET 衬底变成导电性的，由此干扰激励和响应信号。因此，提供了选择工作频率范围、基于那些影响最优频率的因素积极地调谐频率以及相应地调节设备（即，通过选择待测量的滤波器特性或者操作范围内的特定的激励频率）的能力。

[0040] 根据一个实施例，触摸感测设备的触敏膜作为连续结构在平面内延伸。这意味着触敏膜通过像在例如 HARM 网络的情况下例如作为实心的、非中断的、和非图案化的结构在触摸感测设备的整个感测区域上大幅度地延伸，该结构在纳米或微米尺度上并不是严格地连续的。这一结构也是可选择地均质的。当不需要层的图案化时，这一特征不仅将导电层的可见性最小化而且简化了其制造。根据本实施例，其同样简化了具有触敏膜的触摸感测设备的电子设备。

[0041] 触敏膜的良好的灵敏度和触摸位置分辨性能使得这种非图案化的导电层能够在单层操作模式下使用。在单层模式下操作指的是在触摸感测测量中只使用一个单一的导电层。多触摸检测能力在非图案化单层操作模式下也是可用的。这种单层能力同样允许将整个触敏膜生产成为相当薄的结构。

[0042] 在一个实施例中，触敏膜包括：一个单一的条带或者两个或更多个平行的条带，这些条带由导电材料制成并且在触敏膜上向一个方向延伸，以及在所述条带之间的区域，这些区域包括非导电材料，其中，将电气电路电阻地或者无线地耦合到这些条带的每一个，并且处理单元进一步被配置成用于沿着每个条带检测触摸的存在、接近度和位置。

[0043] 将电气电路的电极耦合到每个条带从而为测量提供和接收信号。必须只能在一个维度上确定触摸位置，并且在每个条带上仅使用一个电极来这样做是可能的。

[0044] 在一个实施例中，触敏膜被形成为柔性结构以便允许将其弯曲。“柔性”结构在此指的是优选地允许在至少一个方向上反复地弯曲膜的结构。在一个实施例中，触敏膜至少同时在两个方向上是柔性的。

[0045] 替代柔性或除了柔性以外，触敏膜还可以被形成为一个可变形结构，以便允许例如通过使用热成形使触敏膜沿着三维表面或者在其上变形。

[0046] 触敏膜的柔性和／或可变形性连同测量特征打开了实施触摸感测设备的完全新颖的可能性。例如，用作移动设备的用户接口的触敏膜可以被弯曲成或形成为延伸到设备边缘，这样使得触敏膜甚至可以覆盖设备的整个表面。在覆盖三维设备的不同表面的触敏膜中，可以有若干用于不同目的的触摸感测区域。一个感测区域可以覆盖显示器的区域以便形成触摸屏。其他感测区域（例如在设备的侧面）可以被配置成用作替代常规的机械按钮（例如电源按钮或者音量或亮度滑块或刻度盘）的触敏元件。

[0047] 如下文中更详细描述的，对于柔性的和／或可变形的触敏膜的一个好的选择是包括一个或多个高纵横比分子结构（HARMS）网络的导电层。HARM 结构及其网络固有地是柔性的，因此能够使得触敏膜可弯曲和／或可变形。

[0048] 优选地，触敏膜是光学透明的，因此能够使得触敏膜例如作为触摸屏的一部分使用。触敏膜的光学透明性在此指的是来自于大体上垂直于该膜的平面的方向的入射辐射的至少 10％、优选地至少 90％在待解决的应用的相关频率／波长范围下透射过该膜。在大多

数触摸感测应用中，这一频率 / 波长范围是可见光的频率 / 波长范围。

[0049] 对于光学透明性，关键的是触敏膜的导电材料。同时具有导电性和光学透明性的要求限制了可能的材料的数量。在这个意义上，HARMS 网络为光学透明的触敏膜形成了一个良好的基础，这是因为 HARMS 网络可以优于例如透明导电氧化物提供透明性。

[0050] 在一个实施例中，触敏膜包括高纵横比分子结构 (HARMS) 网络、导电聚合物、石墨烯或陶瓷、金属（如银或金）网格、或金属氧化物。所谓 HARMS 或 HARM 结构此处指的是具有纳米尺度上的特征尺寸（即，小于或等于约 100 纳米的尺寸）的导电结构。这些结构的示例包括碳纳米管 (CNT)、碳 NANOBUD(CNB)、金属纳米线、以及碳纳米带。在 HARMS 网络中，大量的这种单一结构（例如 CNT) 彼此互连。换言之，在纳米尺度上，HARM 结构不形成诸如像导电聚合物或透明导电氧化物之类的真正地连续的材料，而是形成一个电互连分子网络。然而，正如在宏观尺度考虑的，HARMS 网络形成一种实心的整体材料。HARMS 网络可以被制造成一个薄层的形式。

[0051] 借助于敏感膜中的一个或多个 HARMS 网络可实现的多个优点包括在要求光学透明的触敏膜的应用中有用的优良的机械耐用性以及高光透射率，而且还有非常灵活可调的电特性。为了使这些优点最大化，导电材料可以大体上由一个或多个 HARMS 网络组成。

[0052] HARMS 网络的电阻率性能取决于层的密度（厚度）并且在某种程度上也取决于 HARMS 的结构细节（像结构的长度、厚度、或晶体取向）、纳米结构束的直径等。通过 HARMS 制造工艺及其参数的适当选择，这些特性可以被操纵。例如在卡娜图沃伊的 WO 2005/085130 A2 和 WO 2007/101906 A1 中描述了用于生产包括碳纳米结构网络的导电层的合适的工艺。

[0053] 在根据本发明的触摸感测设备的一个实施例中，触摸感测设备包括同样用作触觉界面膜。换言之，该设备进一步包括响应于触摸优选地经由敏感膜用于提供触觉反馈的装置。经由敏感膜提供触觉反馈指的是使用敏感膜作为装置的一部分用于产生触觉反馈，而不是基于附接到触敏膜上的单独的致动器来产生触敏膜的振动的常规方法。对此有各种各样的可能性。通过借助于敏感膜产生适当的一个或多个电磁场可以实现触觉效应。接触触敏膜的用户的皮肤感测这些电场为不同的感觉。这种方法可以被称为电容触觉反馈系统。从另一方面来说，可以交替地将敏感膜用作例如基于电活性聚合物（人造肌肉）的触觉界面的一部分，其中，敏感膜形成该界面的一层。

[0054] 执行这两项功能（即，触摸检测和触觉反馈）的一种可能性是将敏感膜交替地耦合到触摸感测电路以及用于为触觉反馈产生信号的装置，这样使得一旦在第一时间周期内检测到触摸，跟随第一次触摸检测在第二时间周期内提供触觉反馈。可以将第一时间周期和第二时间周期调整的如此短以致用户连续地体验设备操作。

[0055] 可以例如与基于射流技术的触觉接口（通过触觉技术公司 (Tactus Technologies) 商业化）相关联，交替地使用一个或多个触敏膜，其中，触敏膜与柔性的外触觉膜集成，由于液体被泵送到柔性的蓄水池，该柔性的外触觉膜改变形状。一个或多个触敏膜可以位于柔性外触觉膜的内表面和 / 或外表面上。在这种情况下，可以将触敏膜连续地耦合到触摸感测电路。

[0056] 在根据本发明的触摸感测设备的一个实施例中，触摸感测膜同样用作变形检测膜。这意味着该设备结合用于例如感测膜的弯曲、扭转和 / 或拉伸的装置。这可以通过测

量节点之间的电阻的变化或者通过同时与根据本发明的触摸感测一起的信号滤波器特性的变化来实现。由于系统的信号滤波器特性是膜的电阻率的函数，并且，至少对于某些材料（包括但不限于 HARM 和导电聚合物，并且特别是奈米管和 NANOBUD，以及更具体地说，碳纳米管和 NANOBUD）来说，如果膜被例如拉伸、压缩或以其他方式变形，信号滤波器特性会改变。通过或者从电阻率或者从信号滤波器特性的角度解释这种改变，本发明能够检测例如连接到传感器膜的节点之间的延伸或压缩。因此，例如，感测位于相对角落的两组节点之间的延伸指示弯曲，同时在一方向感测延伸并且在另一个方向感测压缩指示扭转。在某些配置中，可以在多个方向使用一个或多个节点来进行感测。根据本发明，替代的配置是可能的。

[0057] 对于某些可变形的外部对象，电容或电感随着施加到触敏膜上的力而变化，并且因此可以将所确定的电容或电感用作力的代理。该力指的是例如当执行触摸时用户施加到设备上的力。当施加在传感器膜附近导致所增加的区域的力时，用户手指例如变形。相应地，这将引起电容发生变化。可替代地，如果使用电感外部对象，并且用户例如使外部对象的线圈变形或者改变从线圈到表面的距离（例如经由弹簧），电感相应地变化并且力也可以被测量。

[0058] 本发明的触摸感测设备可以被实施为一个标准的或定制的独立模块，或者被实施为集成作为某个较大装置（例如，移动电话、便携式或平板计算机、电子阅读器、电子导航仪、游戏控制台、冰箱、搅拌机、洗碗机、洗衣机、咖啡机、炉灶、烤箱或其他白色家电表面、汽车的仪表板或方向盘等）的一部分的一个不可分离的单元。

[0059] 根据本发明的一个实施例，设备的部件之间的无线耦合是下列情形之一：通过无线电波耦合、通过磁场耦合、电感或电容耦合。

[0060] 所谓“设备的部件之间的无线耦合”指的是以上所描述的任何设备元件之间的无线耦合。

[0061] 该设置可能需要处理数据的创建、发送和接收的补充电子设备以及在位于主设备和触摸感测模块两者上的电极之间创建或者静电或者电动感应的 AC 电流。可以将这两种设备无线地或者通过下列方法中的一种或多种耦合到一起：

[0062] －电磁感应（电感耦合、电动感应），其中，通过来自相对线圈之间的磁场的电流所感应的数据和功率传输。

[0063] －磁共振是通过磁场的近场电磁感应耦合。

[0064] －无线电波（例如，RFID 技术），其中，功率从天线接收到的无线电波产生，并且数据传输实质上改变了辐射场负载。

[0065] －电容耦合（或静电感应），其中，从电极的相对平面传递能量和数据。

[0066] 可以或者通过直接地焊接的天线或者经由连接器将触摸传感器完全地或者部分地集成到应用设备。这在固定设施中是足够的，在这些设施中，通常将传感器定位在不需要分离地开放的区域中。例如，在便携式设备中，通常在触摸显示器应用中发现它们，其中，显示器实际上在触摸感测膜的下方并且屏幕自身永久地附接到该设备上。如果触摸感测设备位于设备的可移除部分上，那么其通常会需要一个连接器，一旦其附接到该设备上，通过该连接器其可以连接到该设备上。这种方法是有作用的，但是其在某些应用中可能不适合。此外，即使触摸组件旨在永久地附着到设备上，存在与将组件经由焊料或连接器连接相关联

的制造成本和设计限制。

[0067] 在本发明的一个实施例中，提供了触摸感测设备。其包括：一个触摸感测模块，该模块包括一个触敏膜；电气电路，该电气电路被配置用于为该触摸感测模块提供一个或多个激励信号并且从该触摸感测模块接收一个或多个响应信号。根据本实施例，将电气电路无线地耦合到触摸感测模块。

[0068] 在一个实施例中，将二维的和三维的触摸传感器设备提供给应用，这些应用的外壳盖必须被移除，例如从而维护和改变内部的耐用部件。向设备提供数据输入方法也是一种鲁棒性方法，这些设备对于例如潮湿的、爆炸性的或以其他方式危险的环境或者直接连接（正如互连电线）以其他方式是不可能的、昂贵的或者非常不方便的地方要求完整的封装。

[0069] 在一个实施例中，没有用于功率和数据传输的物理连接器是易受污垢、磨耗及损伤或断裂的影响的。如果没有连接器，有更少的部件易受污染、化学或物理降解或者机械损伤的影响，从而增加设备的可靠性。

[0070] 可以避免直接的物理接触，如果没有受到稳固地保护，其可能会具有无意识的断开并且因此导致数据或功率损耗。其可以起到远离固定设施的远程控制设备的作用，该远程控制设备从该设施获取功率并且作为专门的触摸传感器或通用的数据输入输出设备来工作。

[0071] 通过将触摸传感器功能保留在模块中并且将该模块从主设备分离，它们成为不同的耐用部件，可以单独地生产这些部件并且只在最后的装配时将其组合在一起。可以成本高效地将电极实现为印刷电路板上的金属区域或者印刷线路。

[0072] 根据一个实施例，可以将触摸传感器模块和主设备物理地相互附接，但是功率或数据或者这两者在它们之间无线地传输。实际上，传感器、激励和感测电子设备连同数据处理单元，这样使得整个单元是一个独立的外围设备插件。

[0073] 根据本发明的第二个方面，提供了一种用于用触摸感测设备检测外部对象的存在、接近度、位置、电感、电容或这些特征的组合的方法，该方法包括：提供一个或多个具有至少一个频率、振幅和波形的电激励信号到信号滤波器，该信号滤波器至少由在该触摸感测设备中的触敏膜的电阻和所述膜与外部对象的电容或电感耦合形成，从该信号滤波器接收一个或多个响应信号，并且通过处理所述一个或多个响应信号并且由此测量该信号滤波器的特性的变化来检测由该外部对象进行的触摸的存在、或者所述触摸的位置。

[0074] 触摸感测设备的触摸检测灵敏度和触摸位置分辨率不仅仅取决于信号滤波器的特性和处理装置性能。自然地，其同样是例如接触电极配置的问题。从另一个方面来说，触敏膜的触摸位置分辨率以及利用该触敏膜的触摸感测设备也取决于接触位置的数量以及其相对于彼此和膜的放置。这些是关键的问题，特别是在具有非图案化导电层的单层方法中。通常，例如在 US 7,477,242 B2 和 US 2008/0048996 A1 中所描述的更早已知的这种类型的设备依靠矩形形状的导电层和在其角上的四个接触电极。然而，这种配置需要非常复杂的信号处理，并且这种设备的准确度相当低。根据该解决方案来提供一个柔性结构是特别困难的。同样，多点触摸能力对于实现这种方法可以是非常具有挑战性的。在本发明中，这些困难被减轻或者避免。

[0075] 下面将结合附图在示例的基础上来图示本发明。

[0076] 附图简要说明

[0077] 图 1a、图 1b 和图 1c 展示了根据本发明的触摸感测设备的一种可能的配置。

[0078] 图 2a、图 2b 和图 2c 展示了根据本发明的触摸感测设备的另一种可能的配置。

[0079] 图 3a 和图 3b 是根据一个实施例的二维非图案化的触敏膜的图示。

[0080] 图 4a、图 4b 和图 4c 示出了具有变形感测能力的一个实施例。

[0081] 图 5 展示了另一个实施例,在该实施例中使用了带条纹的触敏膜。

[0082] 图 6 示出了在网格中具有 U 形和 C 形条带的一个实施例。

[0083] 图 7a 和图 7b 是根据本发明的将从触摸感测设备接收的响应信号进行比较的图表。

[0084] 图 8a、图 8b 和图 8c 是所接收的响应信号与激励信号进行比较的图表。

[0085] 发明详细描述

[0086] 本发明的解释基于下文中所描述的示例继续。

[0087] 到外部对象的电容或电感耦合连同电阻膜构成一个电子信号滤波器。由于系统的所得 RC 时间常数,具有足够的电阻率的触敏膜连同具有电容或电感的外部对象创建一个低通 RC 滤波器。这一低通滤波器的特性取决于薄层电阻,也取决于外部对象的位置和电容或电感。

[0088] 在典型的操作模式中,将一个或多个振荡信号或脉冲在一个或多个位置处馈入滤波器。在触敏膜中,在位于触摸表面上或其边缘处的任何两个点之间的电容是其相对位置和传感器区域的几何结构和薄片电阻的函数。在这个系统中的电容或电感是该系统的寄生电容或电感以及在膜和所耦合的外部对象之间形成的电容或电感的组合。除了膜的电阻率之外,当有由一个或多个电容地或电感地耦合的触摸引起的负载呈现在系统中时,电子滤波特性的变化是实质性的。通过测量所提到的信号或脉冲的变化,可以测量电子滤波器特性的变化并且因此可以推断出一个或多个触摸的位置。通过测量例如流入感测膜中的电流的变化,可以计算在传感器和外部对象之间的电容或电感。同样地,每个感测节点(电气电路的一部分,在一个特定的位置连接到触敏膜)的信号变化指示到外部对象的相对距离的变化,并且,通过比较在感测节点处的响应信号之间的差异,连同在传感器节点处的总电流消耗和绝对值的知识,可以通过各种算法来计算触摸的相对位置。例如,采样脉冲的振幅与触摸位置相关并且可以用于确定实际位置。

[0089] 图 1a 示出了一个实施例,其中,将信号提供给节点并且经由同一个节点测量低通滤波器的效果。系统由具有电阻率的触敏膜和电容地或电感地耦合到这一触摸感测膜的外部对象组成。在敏感膜中的某一点处引入信号或脉冲,尽管其可以在膜中的任何地方被引入,但通常在边缘处。可以采用外部组件(如电阻器、恒流源、电容器或电感器或者其组合)来例如增加测量结果的电压线性度,更加均匀地分布电流或电位从而避免系统中的奇异性并且允许电流或电压电位被测量。外部组件连同电阻膜和外部触摸对象创建一个低通滤波器。信号耦合到由触摸膜和外部对象创建的负载,并且,通过改变系统的低通滤波器特性,从而变更信号。在外部组件和触敏膜之间采样(接收)所变更的信号。对于测量两个或更多个外部对象的多点触摸,测量原理类似于单点触摸的情形,区别是并非是一条而是形成了多达两条或更多条到外部对象电容或电感的平行通路并且电容或电感耦合增加。取决于外部对象的位置和电容或电感以及信号与由触摸膜、外部组件和外部对象形成的低通滤波

器的交互，采样信号是不同的。采用多个输入／感测节点允许更加确切地指定触摸的位置和外部对象的电容或电感。在本实施例中，为了指定 x 和 y 位置以及电容或电感，每个触摸需要 3 个节点（这些节点可以在各种可能的组合中作为输入和感测节点使用），从而例如对于 4 个同时的触摸，需要 12 个输入和感测节点。

[0090]　在图 1b 的方框图中示出了根据图 1a 的本实施例的更一般的配置，并且在图 1c 中展示了一个具体的实施例，在该实施例中，经由三个外部组件将三个信号或脉冲提供给触摸膜上的三个点（节点）。然后将采样信号或脉冲与源信号或脉冲或者其他采样信号或脉冲进行比较从而确定外部对象的位置和／或电容或电感。

[0091]　图 2a 示出了一个示例性实施例，其中，将信号馈入节点并且在一个或多个相对的或相邻的节点中测量低通滤波器的效果。系统包括具有电阻率的敏感膜和电容地或电感地耦合到这一敏感膜的外部对象。在敏感膜中的节点处引入信号或脉冲，通常在边缘处（尽管可以在任何地方将其引入）并且在不同的位置处接收所变更的信号。取决于外部对象的位置和电容或电感以及信号与由触摸膜和外部对象形成的低通滤波器的交互，所接收的信号是不同的。对于单个或者多个输入节点，使用多个感测节点允许更加确切地指定触摸的位置和外部对象的电容或电感。在本实施例中，为了指定 x 和 y 位置以及电容或电感，每个触摸需要 3 个输入和感测节点，从而例如对于 4 个同时的触摸，需要 12 个输入和感测节点。

[0092]　在图 2b 的方框图中示出了根据图 2a 的本实施例的更一般的配置，并且在图 2c 中展示了一个具体的实施例，在该实施例中，经由三个外部组件将三个信号或脉冲提供给触摸膜上的三个点（节点）。然后将采样信号或脉冲与源信号或脉冲或者其他采样信号或脉冲进行比较从而确定外部对象的位置和／或电容或电感。

[0093]　在图 1b、图 1c、图 2b 和图 2c 中，框“信号／脉冲发生器”表示一个发生器，该发生器产生例如一个或多个激励电压或电流脉冲或振荡（激励信号），其可以是例如正弦曲线、三角形、方形或者锯齿形的形式。如果需要，其也可以包括其他功能性，如控制单元和／或时钟。“信号比较器”框指示一种设备，该设备比较并且区分激励和／或响应信号并且将这个信息提供给解释单元。其可以比较例如电压或电流频率、振幅、相移或波形状或波形。“解释单元”框表示一个单元，该单元处理从信号比较器发出的信号并且同样可能地使用来自信号／脉冲发生器（例如来自时钟或控制功能）的信息。如果需要，其也可以包括其他功能性，如控制单元和／或时钟。其也可以提供信息给例如信号／脉冲发生器（例如来自时钟或控制功能）。实际上，所有这些功能可以被结合到单个单元或者芯片并且因此可以不是单独的。

[0094]　可以将激励信号发送到单个节点并且可以顺序地或者同时地对响应信号进行相应地采样。此外，可以将相同的或不同的激励信号发送到单个节点。这些激励信号可以是来自相同的或不同的源的。

[0095]　图 3a 是一个实施例的图示，在该实施例中使用了一个具有多个输入信号或脉冲（其可以是来自单个或多个源的）的二维触敏膜。在这个示例中，将三个外部组件各自串联放置在源和本质上二维的敏感膜或者敏感薄片之间，并且在外部组件和敏感膜之间对信号进行采样。在没有触摸的情况下，采样信号相对于滤波器的特性将具有一个给定的特性形式。当触摸发生时，到外部对象的电容或电感耦合改变滤波器特性。或者对于彼此或者对于输入信号，采样信号之间的关系提供有关特性的这一变化并且因此有关外部对象的位

置和电容或电感的信息。在本实施例中，为了指定 x 和 y 位置以及电容或电感，每个触摸需要 3 个输入和感测节点，从而例如对于 4 个同时的触摸，需要 12 个输入和感测节点。因此，图 3a 示出了用于充分地指定就位置和电容或电感而言的单个触摸的最小数量的节点。图 3b 示出了其另一个实施例，其中，将四个外部组件各自串联放置在源和本质上二维的敏感膜或者敏感薄片之间，并且在外部组件和敏感膜之间对信号进行采样，这是为了增加单个触摸的准确度或者是为了例如允许多个触摸的存在的确定。在此描述的二维触敏膜对于 3D 表面也可以是柔性的和 / 或可变形的。

[0096] 图 4a 至图 4c 示出了具有单层膜的感测膜变形的示例，在这些图中，敏感膜交替地耦合到触摸感测电路或算法以及耦合到变形感测电路或算法。在这种情况下，至少需要三个节点来执行测量。可以通过 DC 电压电平测量节点之间的电阻的变化来确定变形。

[0097] 实际上，传感器变形、扭转或弯曲可能会通过改变再次改变滤波器特性的有源区域电阻率来影响触摸感测。然而，在这种情况下，触敏膜仍然可以至少在一种模式下使用，其中，当相同的膜变形时，其用作变形传感器，以及当其没有变形时，其用作触摸传感器。

[0098] 图 5 展示了具有多个输入信号或脉冲（其可以是来自单个或多个源的）的二维触摸传感器的一个实施例。将外部组件 51 串联地放置在一个源或多个源和单个或一组本质上一维的感测膜（单个感测指状物或条带 52 或其集合）之间，并且在外部组件和感测膜之间采样信号。对于良好性能，这些条带应该具有高纵横比，例如，长宽比应该大于 3，或者更优选地，大于 10。这些条带可以是例如直的或弯曲的并且不需要具有恒定的宽度。在单一条带的情况下，该实施例可以充当滑块或拨号盘。在没有触摸的情况下，采样信号相对于滤波器的特性将具有给定的特性形式。当触摸发生时，到外部对象的电容或电感耦合改变滤波器特性。采样信号与输入信号之间的关系从而提供有关外部对象的位置和任何给定的条带中的触摸的存在的信息。同样为了检测外部对象的电容或电感，可以从膜上（优选地在条带 52 的对端）进行一次或多次额外的采样。在本实施例中，为了指定沿着条带的触摸位置（例如 x 位置）以及在所述条带上的触摸的电容或电感，每个触摸需要 2 个输入和感测节点，从而例如对于沿着任何条带的 4 个同时的触摸，需要 8 个输入和感测节点。可以根据图 1a 和图 2a 的两种配置对此进行操作。在基本上正交的例如 y 方向上的触摸的位置是通过标识在特定条带上的触摸的存在确定的。

[0099] 这种配置的修改是为了将每个条带制作成“U”形或“C”形，这样使得在每个条带两个电极的情况下，电极位于触摸区域的相同侧或边缘。这可以增加设备的准确度并且允许沿着一个边缘定位所有的接触电极，从而允许设计自由并且降低对例如将触摸区域的一个或多个边缘磨成斜面的需要。

[0100] 也可以在一个双层结构中使用图 6 的配置，每一层具有一组条带，其中，一层的条带被定向以便不会与另一层的条带平行。优选地，定向在 90 度。以此方式，形成了网格结构。图 5 示出了与“U”形或“C”形条带相结合的这种配置。通常，应该通过例如气隙或绝缘或介电材料将这些层分离。衬底或 / 和涂层可以充当这种绝缘子或电介质。

[0101] 图 5 和图 6 中的标记“AC 输入”和“AC 输出”可以分别意指信号或脉冲输入和输出。

[0102] 图 7a 是一个图表，示出了来自于在具有统一电阻率的二维长方形触摸表面上的触摸的响应信号的比较和六个接触电极，其中的两个接触电极位于中线边缘并且彼此相

对。当触摸初始地从中线稍微地向左偏移继而短暂地位于中线上但是稍微地偏离中心朝向顶部然后最终稍微地偏向右侧时，该图示出了在这两个接触节点之间的响应信号之间的区别。该图示出了不同感测节点（接收电极）之间的信号差异，即，根据权利要求 4 的实施例进行测量。当在距相对感测节点相等的距离和角度进行触摸时，如第二和第六幅图的情况一样，在理想情况下，差异为零。这清晰地示出了滤波器特性的变化是如何影响信号的以及例如如何可以测量到触摸位置。

[0103]　在图 7b 中，如同在真实系统的情况下，在固定的间隔处对图 7a 中的信号进行采样。

[0104]　类似地，与在不同节点处的响应信号的差异截然相反的是，可以采用响应信号和激励信号之间的差异来确定滤波器特性的变化并且因此唯一地确定触摸的存在、接近度、位置和触摸对象的电容或电感。图 8a 至图 8c 示出了类似于图 7a 和图 7b 的响应信号和激励信号的比较。由于凭视觉观察信号的差异是困难的，图 8c 显示了当在时间位置 120μs 处移除触摸时响应信号 vs. 激励信号的差异。

[0105]　也可以使用响应信号的其他特性来标识滤波器特性（如电压或电流波形或形状、振幅或相移）的变化。可以自由地选择在滤波器特性的变化的确定中有待采样和使用的一个特性或多个特性，从而使得例如将信噪比最大化。此外，可以选择激励信号的频率、波形状（例如正弦曲线、三角形、方形、锯齿形等）和振幅来例如避免干扰或者将信噪比最大化。

[0106]　本发明不限于以上所描述的示例，但是这些实施例可以在权利要求书的范围内自由地变化。

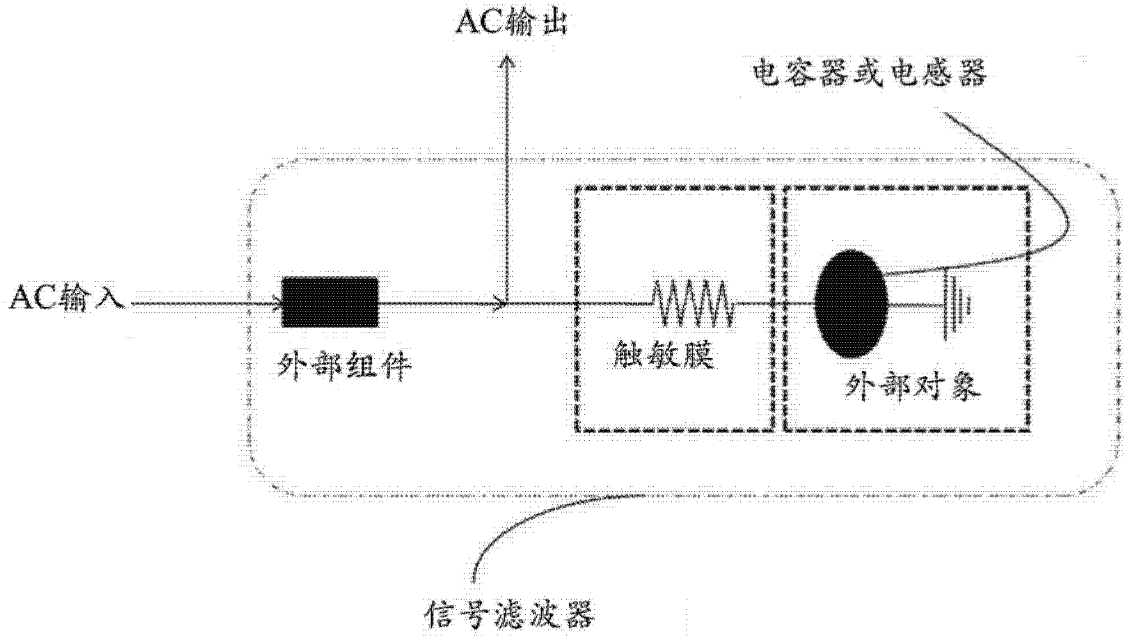

AC输出
电容器或电感器
AC输入
外部组件
触敏膜
外部对象
信号滤波器

图 1a

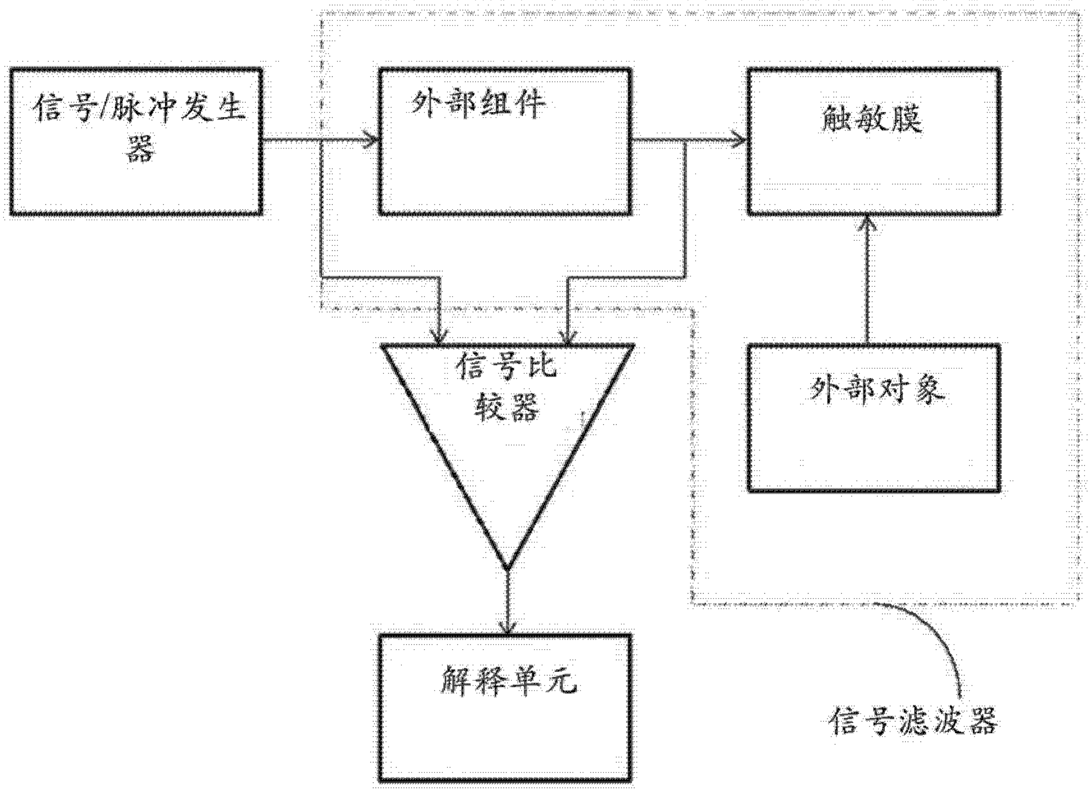

信号/脉冲发生器
外部组件
触敏膜
信号比较器
外部对象
解释单元
信号滤波器

图 1b

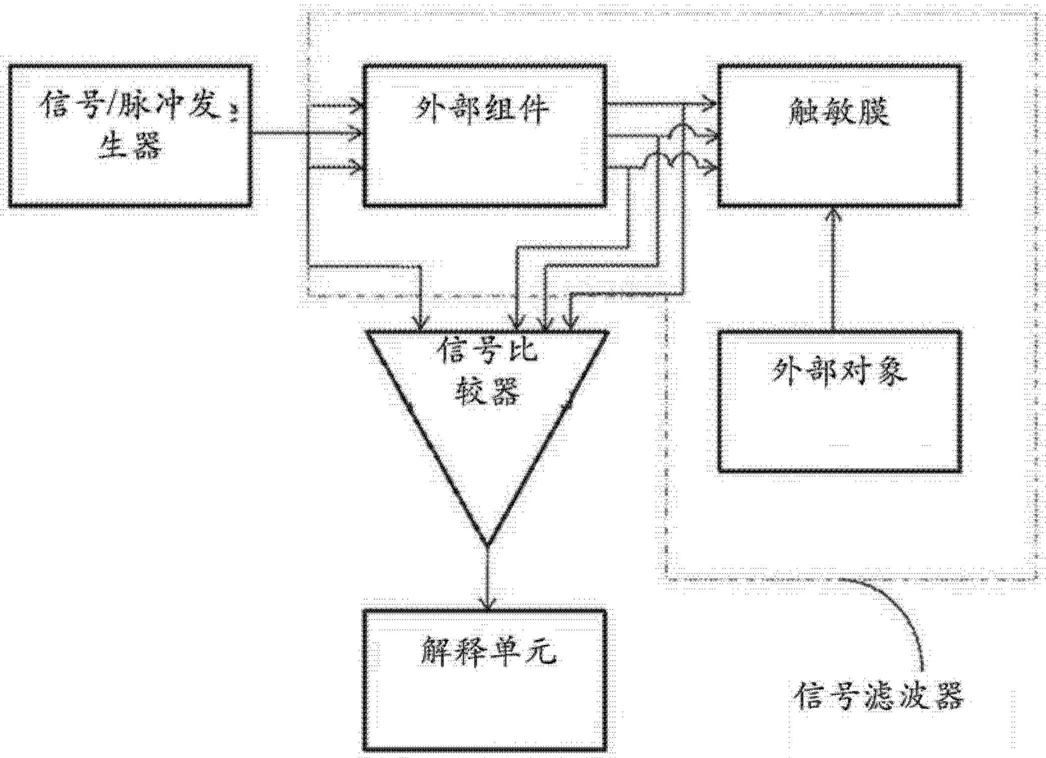

信号/脉冲发生器
外部组件
触敏膜
信号比较器
外部对象
解释单元
信号滤波器

图 1c

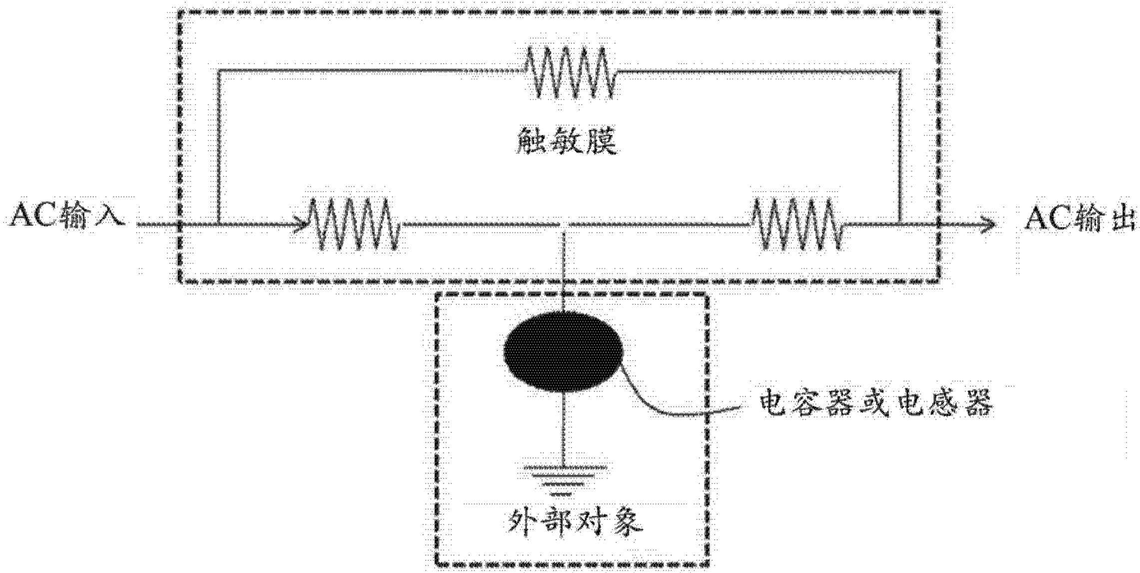

触敏膜
AC输入
AC输出
电容器或电感器
外部对象

图 2a

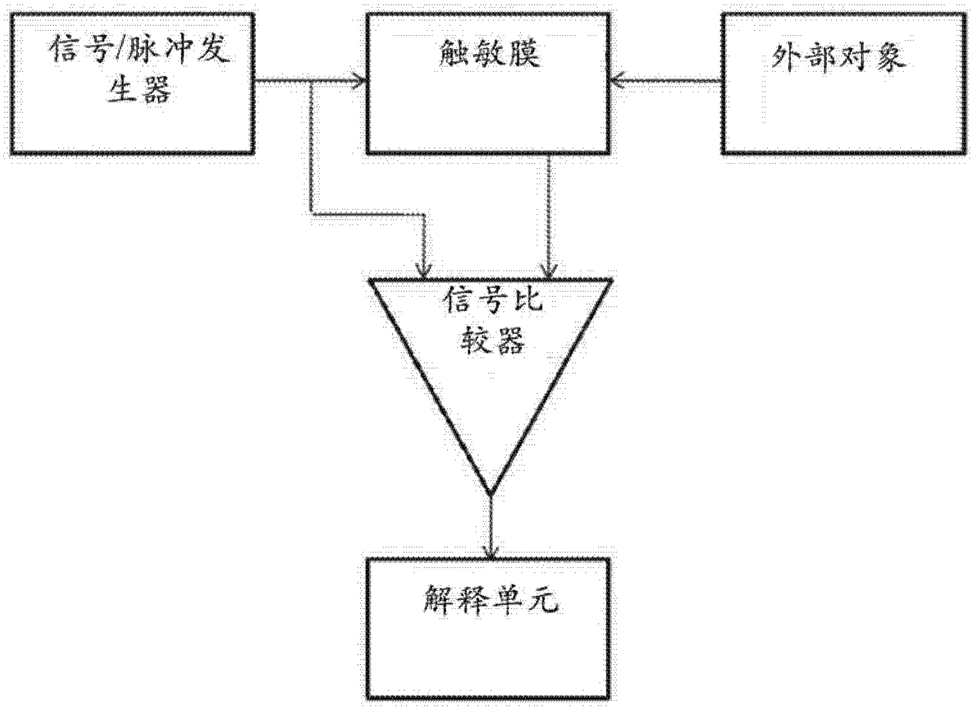


图 2b

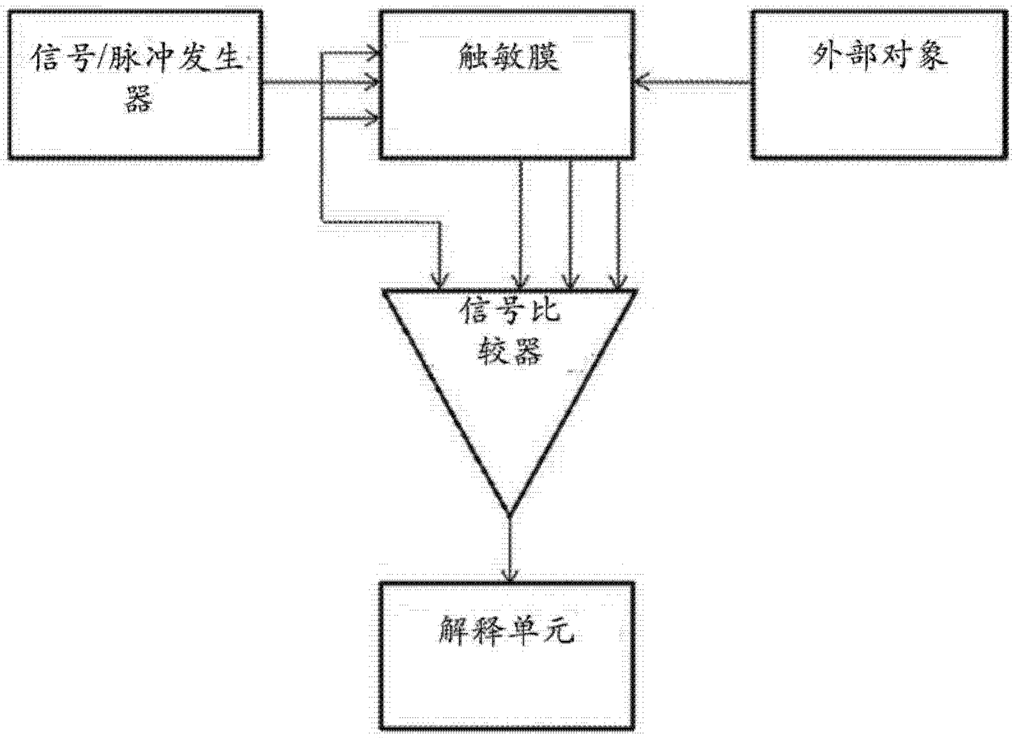


图 2c

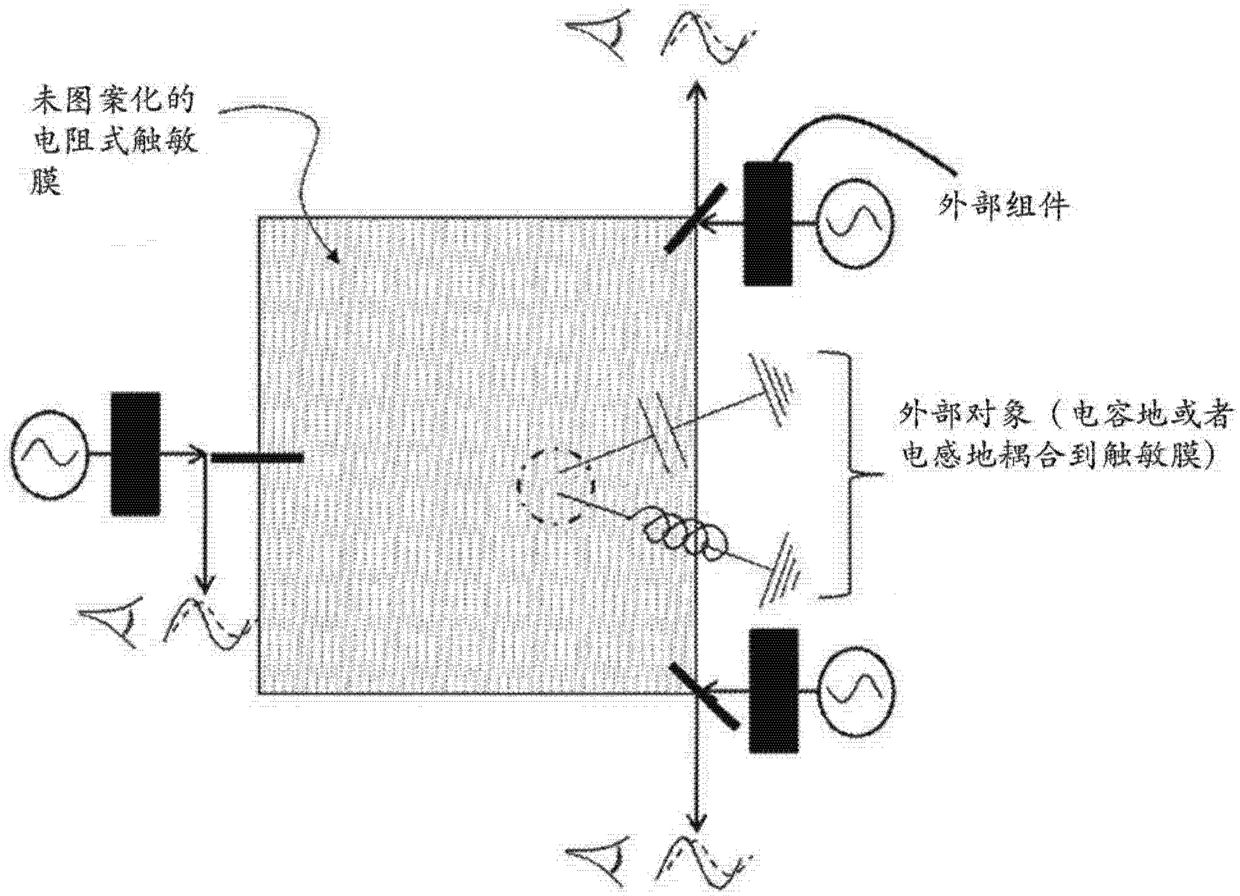


图 3a

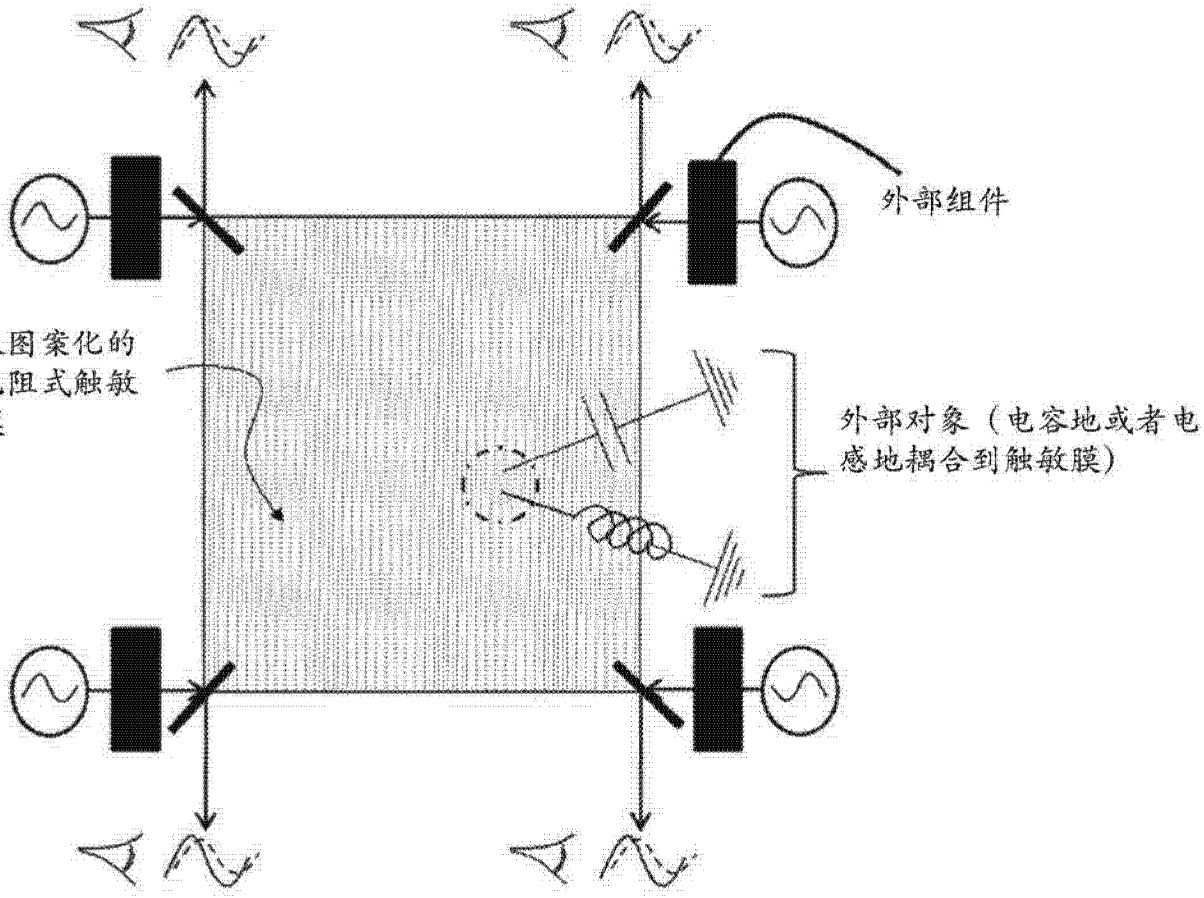


图 3b

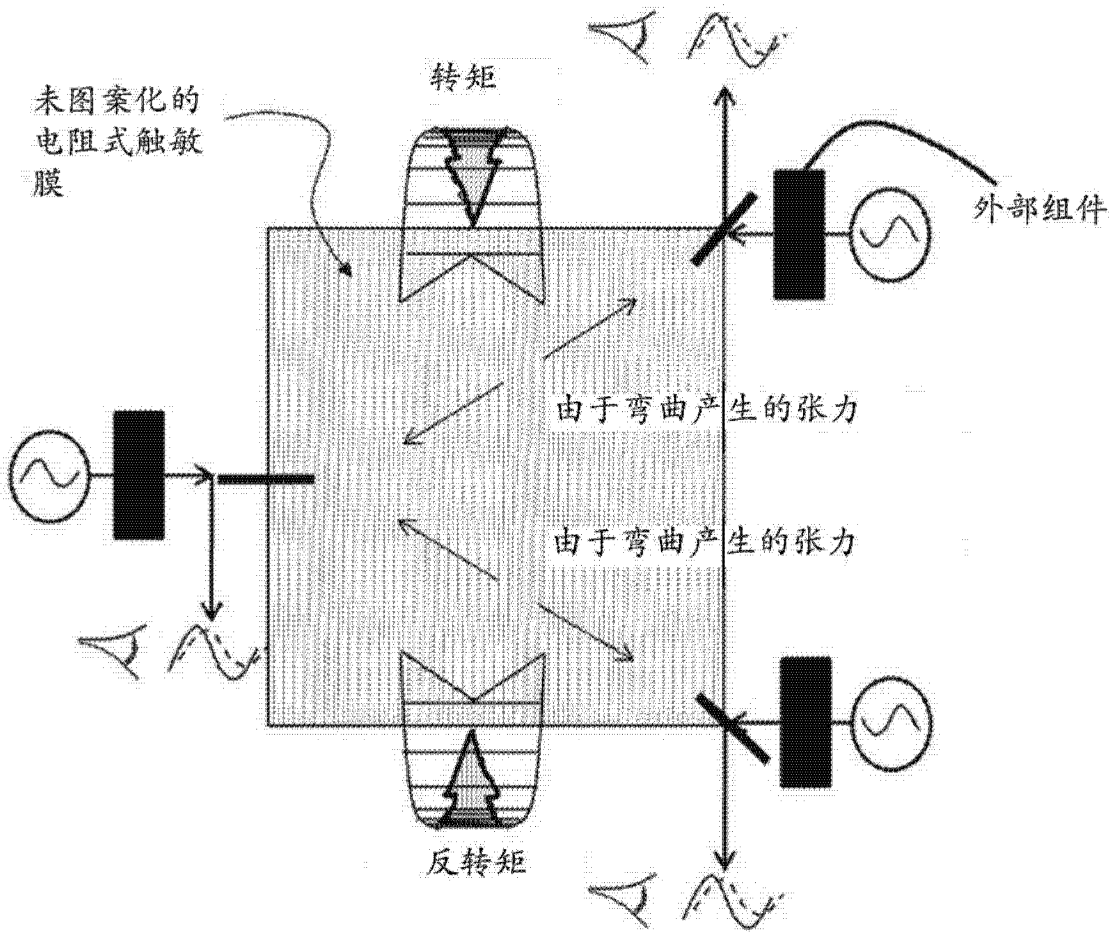


图 4a

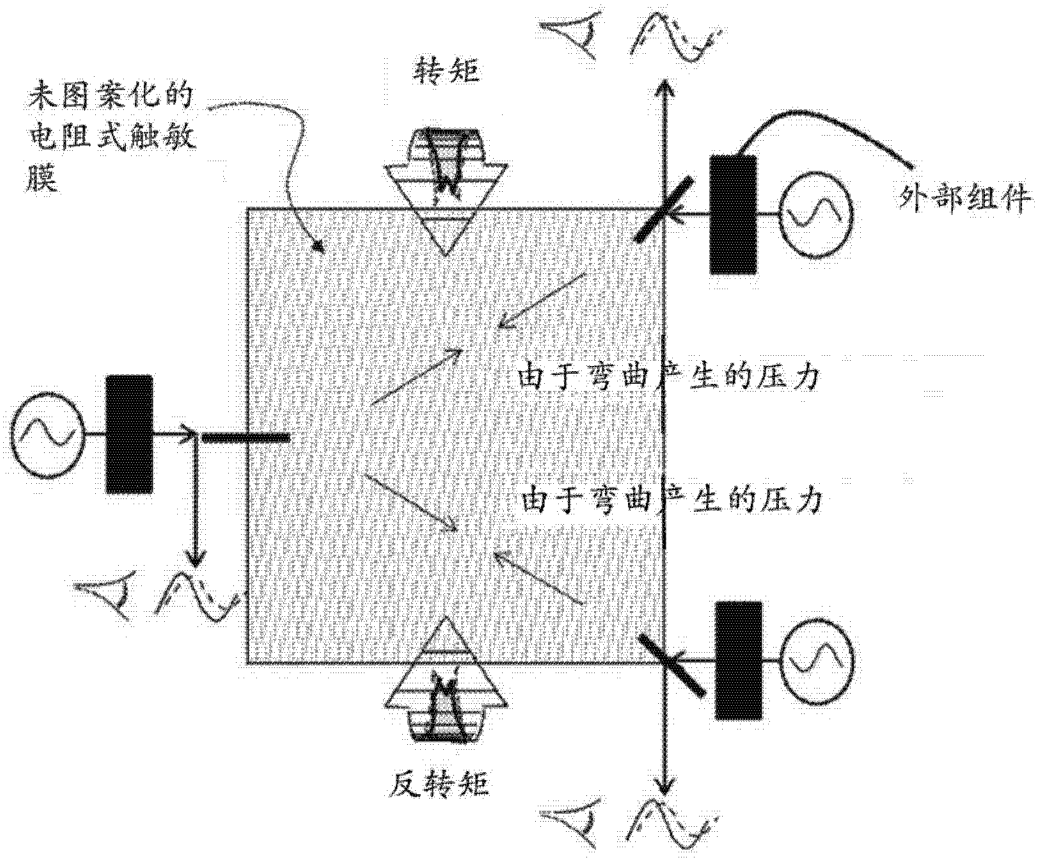


图 4b

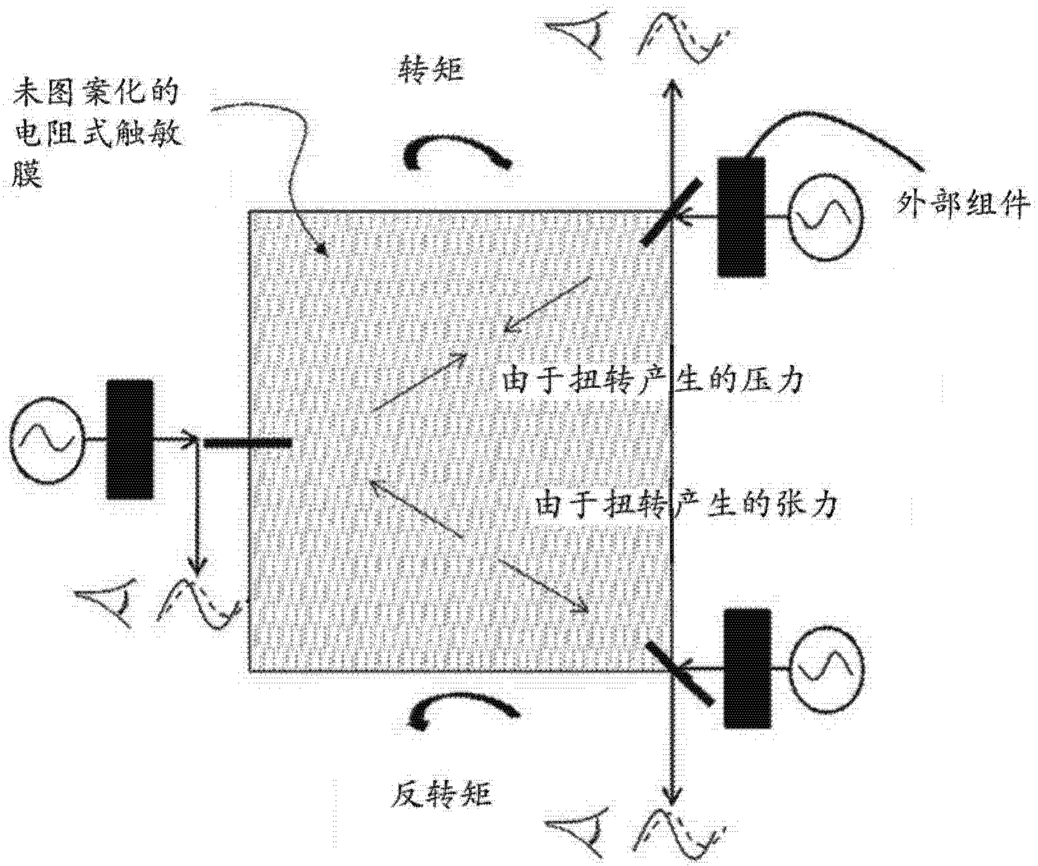


图 4c

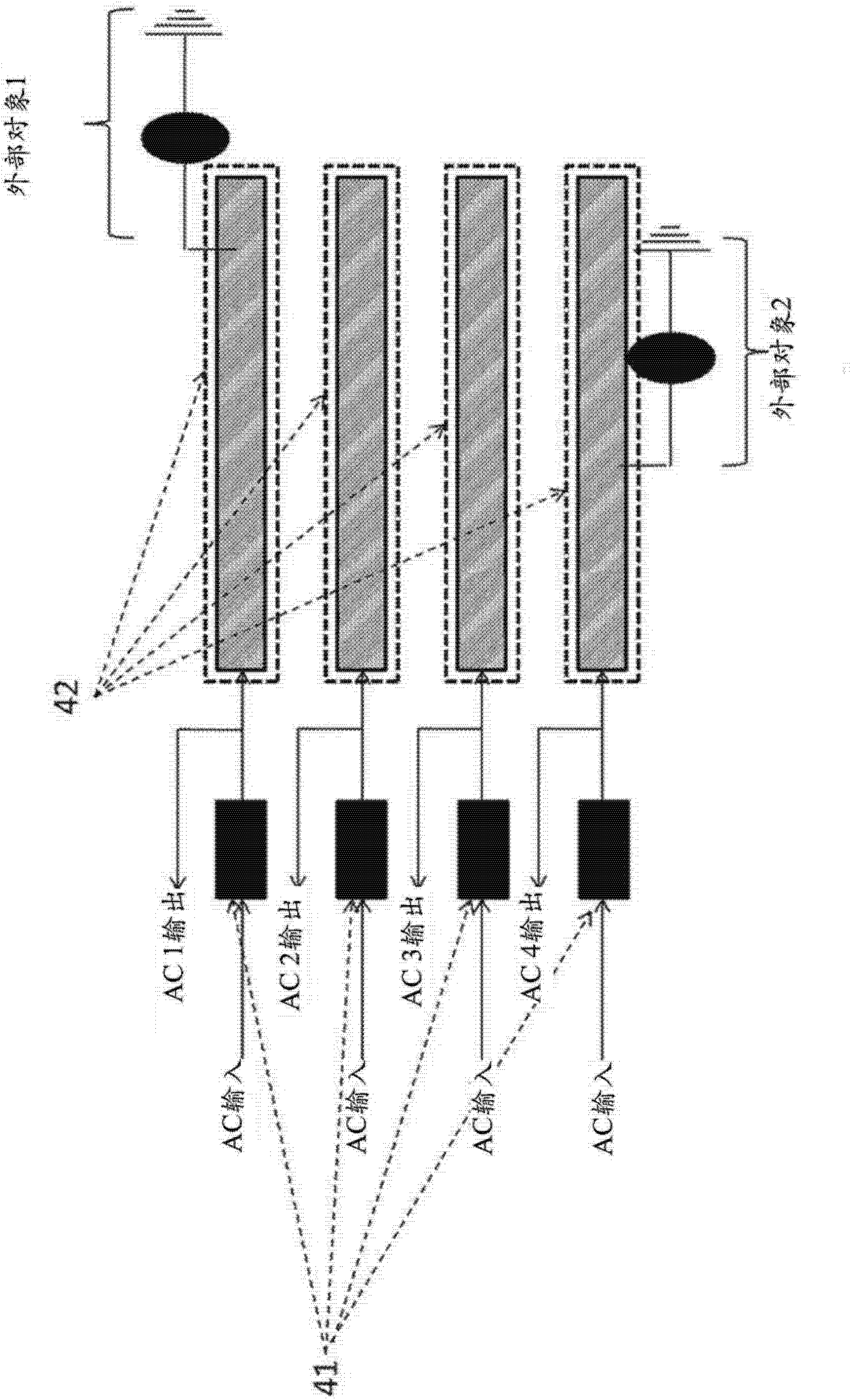

外部对象1
外部对象2
42
AC 1输出
AC 2输出
AC 3输出
AC 4输出
AC输入
AC输入
AC输入
AC输入
41

图 5

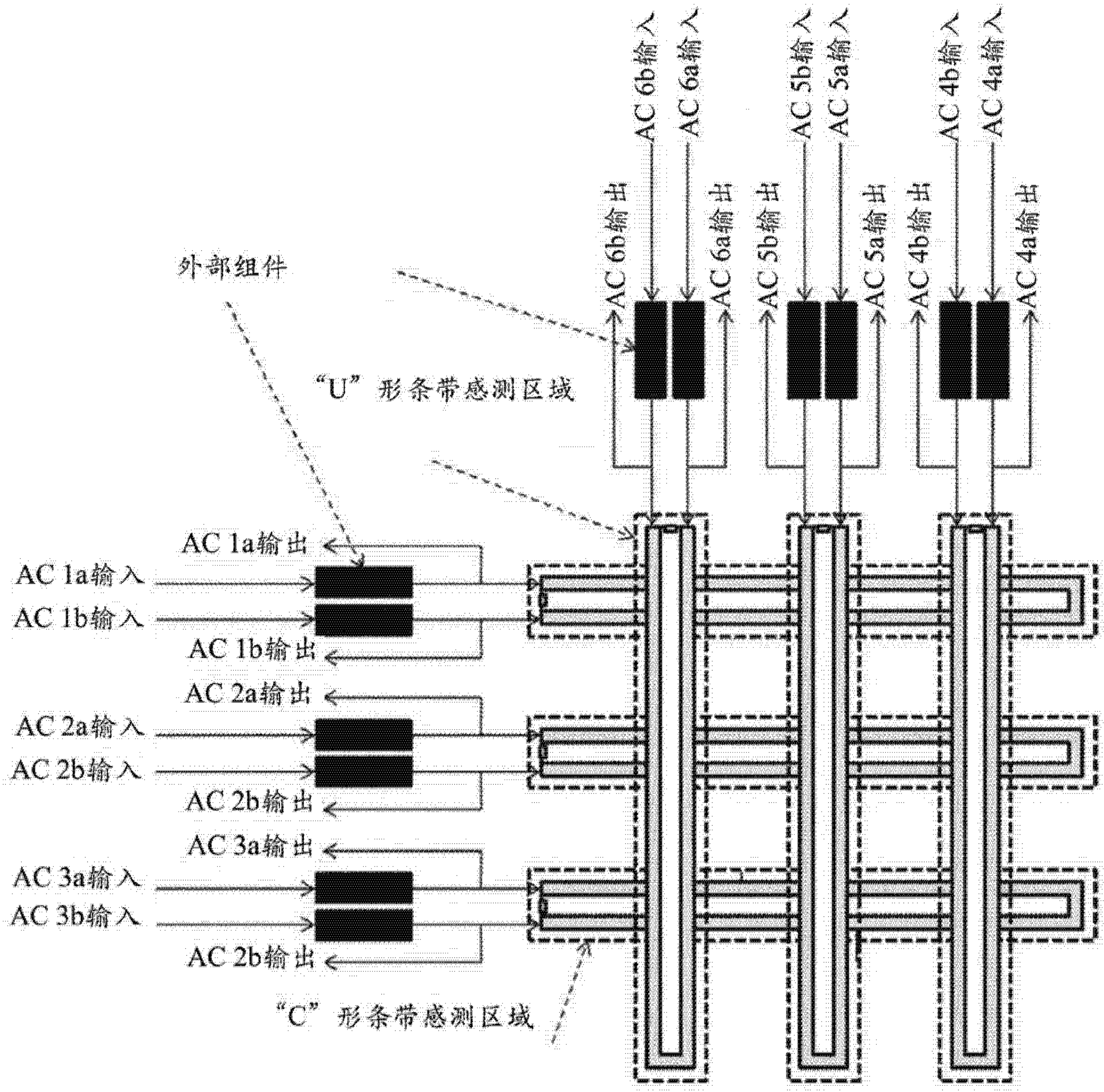

AC 6b输入
AC 6a输入
AC 5b输入
AC 5a输入
AC 4b输入
AC 4a输入
AC 6b输出
AC 6a输出
AC 5b输出
AC 5a输出
AC 4b输出
AC 4a输出
外部组件
"U"形条带感测区域
AC 1a输出
AC 1a输入
AC 1b输入
AC 1b输出
AC 2a输出
AC 2a输入
AC 2b输入
AC 2b输出
AC 3a输出
AC 3a输入
AC 3b输入
AC 2b输出
"C"形条带感测区域

图 6

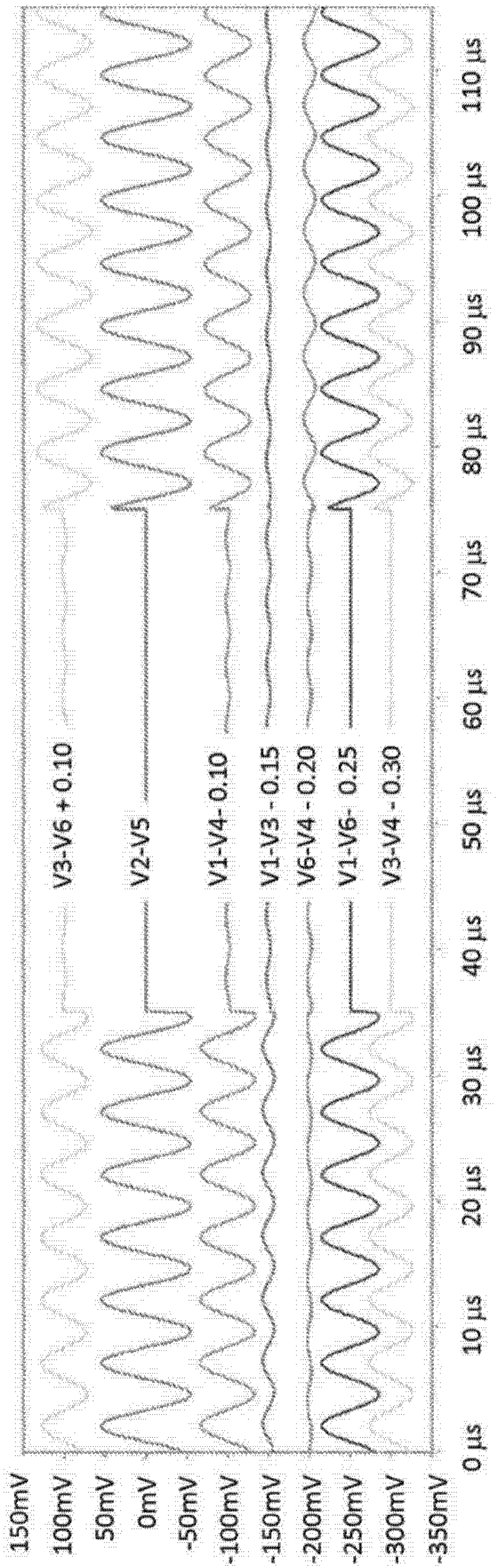

V3-V6 + 0.10
V2-V5
V1-V4- 0.10
V1-V3 - 0.15
V6-V4 - 0.20
V1-V6- 0.25
V3-V4 - 0.30
150mV
100mV
50mV
0mV
-50mV
-100mV
-150mV
-200mV
-250mV
-300mV
-350mV
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

图 7a

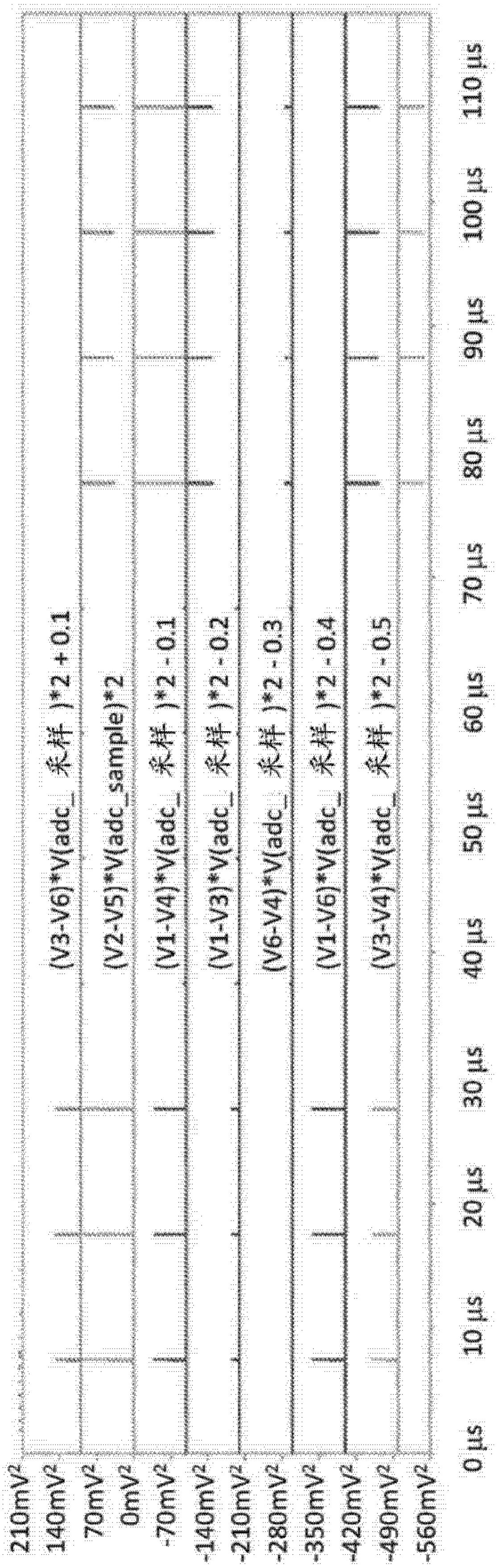

(V3-V6)*V(adc_ 采样)*2 + 0.1
(V2-V5)*V(adc_sample)*2
(V1-V4)*V(adc_ 采样)*2 - 0.1
(V1-V3)*V(adc_ 采样)*2 - 0.2
(V6-V4)*V(adc_ 采样)*2 - 0.3
(V1-V6)*V(adc_ 采样)*2 - 0.4
(V3-V4)*V(adc_ 采样)*2 - 0.5
210mV²
140mV²
70mV²
0mV²
-70mV²
-140mV²
-210mV²
-280mV²
-350mV²
-420mV²
-490mV²
-560mV²
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

图 7b

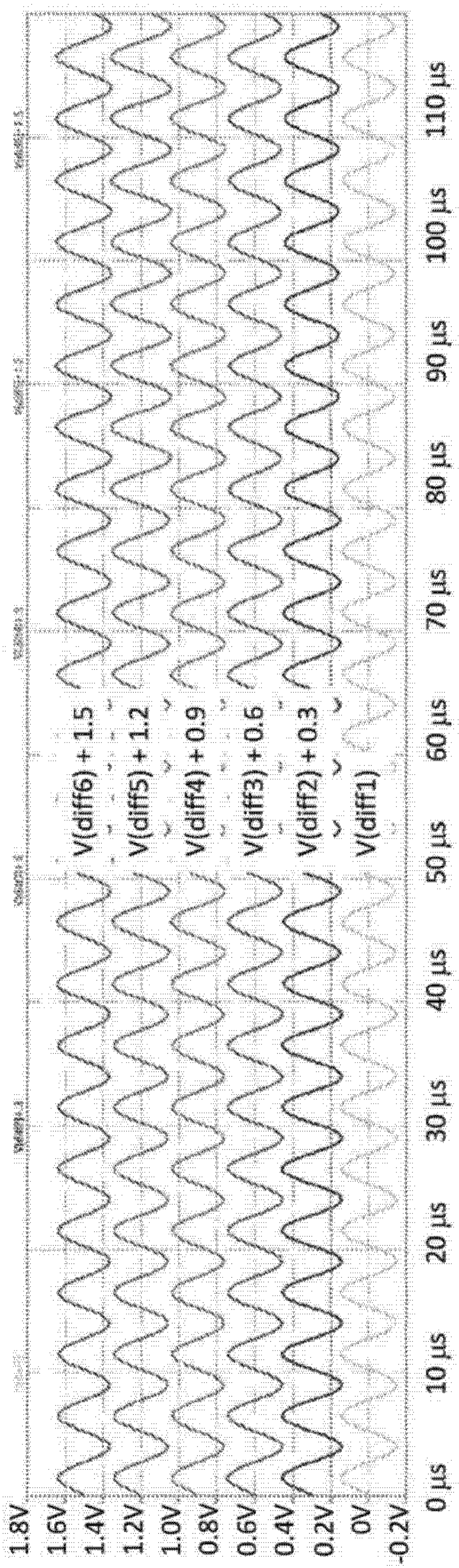

V(diff6) + 1.5
V(diff5) + 1.2
V(diff4) + 0.9
V(diff3) + 0.6
V(diff2) + 0.3
V(diff1)
1.8V
1.6V
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0V
-0.2V
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

图 8a

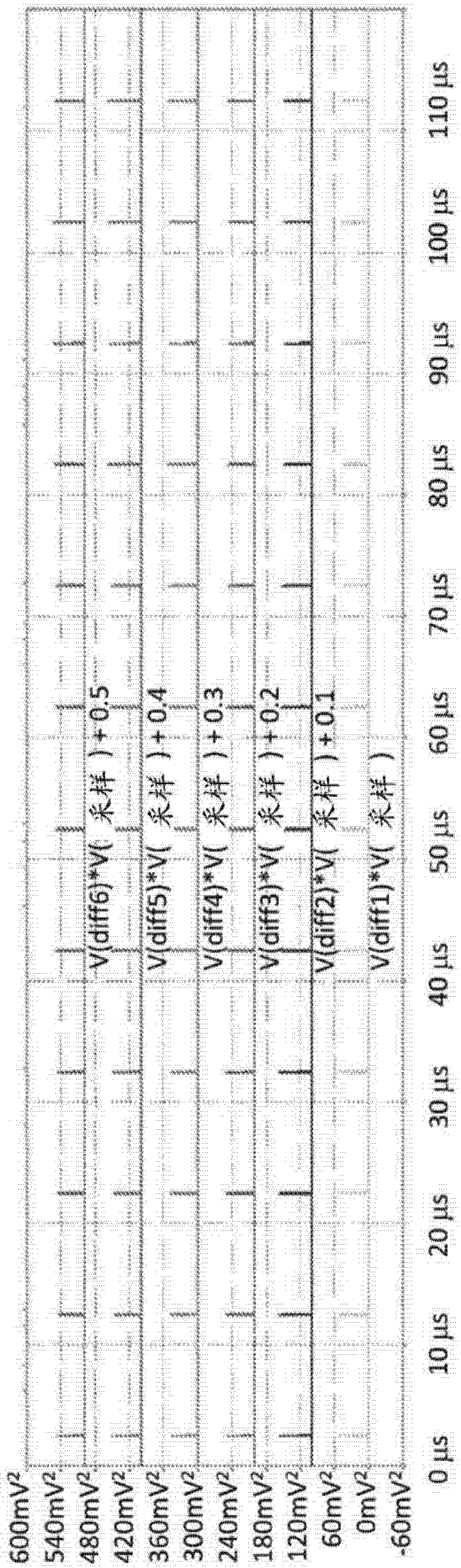

V(diff6)*V(采样)+0.5
V(diff5)*V(采样)+0.4
V(diff4)*V(采样)+0.3
V(diff3)*V(采样)+0.2
V(diff2)*V(采样)+0.1
V(diff1)*V(采样)
600mV²
540mV²
480mV²
420mV²
360mV²
300mV²
240mV²
180mV²
120mV²
60mV²
0mV²
-60mV²
0 µs
10 µs
20 µs
30 µs
40 µs
50 µs
60 µs
70 µs
80 µs
90 µs
100 µs
110 µs

图 8b

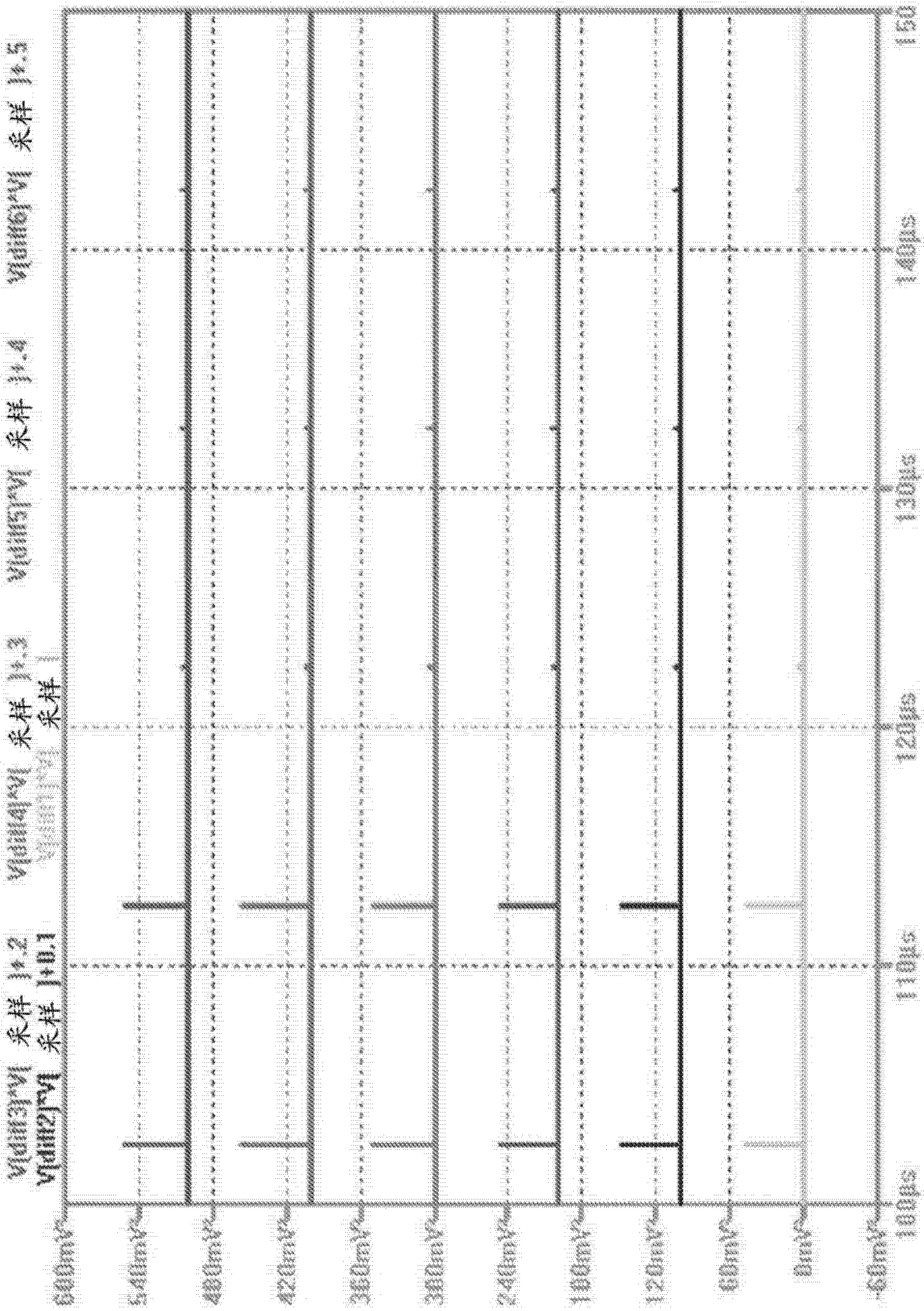

600mV
540mV
480mV
420mV
360mV
300mV
240mV
180mV
120mV
60mV
0mV
-60mV
100μs
110μs
120μs
130μs
140μs
150

图 8c

Abstract

A touch sensing device, comprising: a touch sensitive film, a signal filter, electrical circuitry and a processing unit. According to the invention, the film is capable of capacitive or inductive coupling to an external object when a touch is made by the object. The signal filter is formed at least by the resistance of the film and the capacitive or inductive coupling to the external object,and the filter has properties affected at least by location of the touch and/or capacitance or inductance of the touch. The electrical circuitry is coupled to the touch sensitive film at one or more locations and configured to supply one or more excitation signals at least one frequency, amplitude and wave form into the signal filter and to receive one or more response signals from the signal filter. The processing unit is coupled to the electrical circuitry and is configured to detect the presence or proximity of a touch by the external object, the location of said touch, the capacitance and/or inductance of said touch by processing one or more response signals and thereby measuring changes in the properties of the signal filter.