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(54) Title: TOUCH DETECTION DEVICE

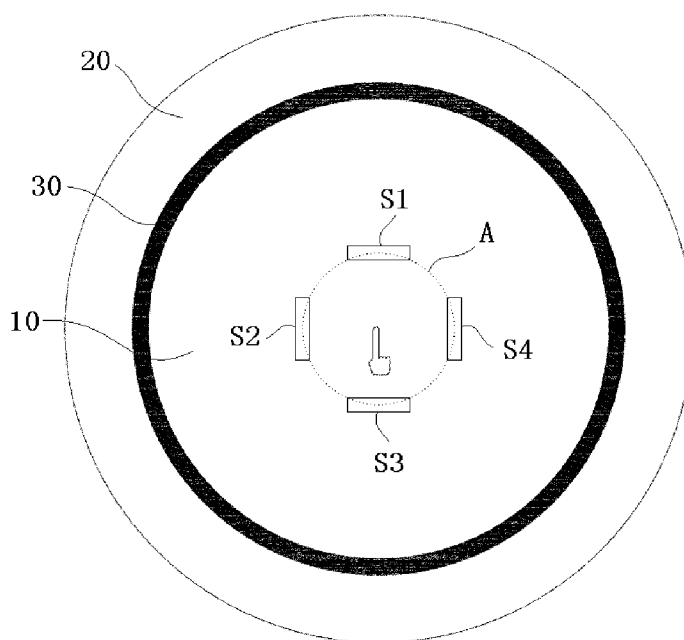


Fig.1

(57) Abstract: A touch detection device includes: a touch panel; a plurality of piezoelectric sensors mounted on the touch panel and adapted to detect a knock event applied to the touch panel; and a control circuit board electrically communicated with the piezoelectric sensors. The control circuit board includes: a plurality of signal processing circuits connected to the plurality of piezoelectric sensors, respectively, and configured to process the detection signals output from the plurality of piezoelectric sensors, respectively; and a controller adapted to determine whether the knock event is occurred within a specified area on the touch panel based on the processed detection signals. The touch detection device may conveniently and accurately identify whether the knock event applied on the touch panel is occurred within a specified area on the touch panel.



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Touch Detection Device

CROSS-REFERENCE TO RELATED APPLICATION

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This application claims the benefit of Chinese Patent Application No. 201811258132.9 filed on October 26, 2018 in the State Intellectual Property Office of China, the whole disclosure of which is incorporated herein by reference.

10 BACKGROUND OF THE INVENTION

Field of the Invention

At least one embodiment of the present disclosure relates to a touch detection device,
15 more particularly, relates to a touch detection device comprising a piezoelectric sensor.

Description of the Related Art

In order to increase the convenience of controlling a device (for example, household
20 appliances), touching or knocking a surface of the device by a finger is a visual and convenient Man-Machine Interaction. In the related art, a capacitance touch panel is usually used. However, if the touch area of the device is very large, such as when a whole door of a washing machine or a refrigerator is used as a touch input surface, the cost thereof becomes very high. At the same time, since the capacitance value is changed once the capacitance
25 touch panel is touched, it cannot distinguish the touch force and the touch material. In other words, the capacitance touch panel will be triggered as long as it is touched, which will cause many false triggers. In some conditions, an input instruction to control the device is defined as an event of knocking or touching a surface of the device with a specific finger part, such as finger joint or fingertip. For example, an input instruction to open a light inside
30 a refrigerator may be defined as a double-click event on the refrigerator door, an input instruction to open a dishwasher may be defined as a knock event on the dishwasher door, an input instruction to open a washer barrel lamp may be defined as a double-click event on the washer door, an input instruction to open a washer door may be defined as a triple-click event on the washer door.

35 In addition to the capacitance touch panel, in the related art, there are also some other solutions to control the device, for example, using a microphone to detect sound signals or using an acceleration sensor to detect vibration signals. In the solution of using the microphone to detect sound signals, it needs to form a closed voice cavity in the device,

thereby the installation of the device is very troublesome and the cost thereof is high. In the solution of using the acceleration sensor to detect vibration signals, it needs to mount the accelerometer on the circuit board in a surface mounted manner, and it is needs to ensure the accelerometer to tightly contact a vibration surface of a vibration plate. When the vibration plate to be knocked is made of transparent material, such as, transparent glass, it is very difficult to hide the circuit board, causing great design challenges.

In addition, in some applications, the device generates a response only when the knock event occurs in a specified area on a surface of a touch panel, and there will be no response when the knock event occurs outside the specified area. However, in the related art, it is difficult to distinguish the specified area (or referred as a response area) and a nonresponse area on the surface of the touch panel by using the piezoelectric sensors.

SUMMARY OF THE INVENTION

The present disclosure has been made to overcome or alleviate at least one aspect of the above mentioned disadvantages.

According to an aspect of the present disclosure, there is provided a touch detection device, comprising: a touch panel; a plurality of piezoelectric sensors mounted on the touch panel and adapted to detect a knock event applied to the touch panel; and a control circuit board electrically communicated with the piezoelectric sensors. The control circuit board comprises: a plurality of signal processing circuits connected to the plurality of piezoelectric sensors, respectively, and configured to process the detection signals output from the plurality of piezoelectric sensors, respectively; and a controller adapted to determine whether the knock event is occurred within a specified area on the touch panel based on the processed detection signals.

According to an exemplary embodiment of the present disclosure, each of the signal processing circuits comprising: a filter configured to filter out noise signals that are not satisfied with a predetermined condition from the detection signal; an amplifier configured to amplify the filtered detection signal to a desired range; and a comparator comprising an upper-threshold comparator with a predetermined upper-threshold voltage and a lower-threshold comparator with a predetermined lower-threshold voltage to process the amplified detection signal into a first DC voltage digital signal and a second DC voltage digital signal.

According to another exemplary embodiment of the present disclosure, the controller is configured to determine whether the knock event is occurred within the specified area on the touch panel based on the first DC voltage digital signals and the second DC voltage digital signals output from the plurality of signal processing circuits.

According to another exemplary embodiment of the present disclosure, the first DC voltage digital signal output from the upper-threshold comparator corresponds to the

negative half period of the detection signal output from the piezoelectric sensor; and the second DC voltage digital signal output from the lower-threshold comparator corresponds to the positive half period of the detection signal output from the piezoelectric sensor.

5 According to another exemplary embodiment of the present disclosure, when the controller detects that all output signals firstly output from the plurality of signal processing circuits are the first DC voltage digital signals or that all output signals firstly output from the plurality of signal processing circuits are the second DC voltage digital signals, the controller determines that the knock event is occurred within the specified area on the touch panel.

10 According to another exemplary embodiment of the present disclosure, when the controller detects that not all output signals firstly output from the plurality of signal processing circuits are the first DC voltage digital signals or that not all output signals firstly output from the plurality of signal processing circuits are the second DC voltage digital signals, the controller determines that the knock event is occurred outside the specified area on the touch panel.

15 According to another exemplary embodiment of the present disclosure, the specified area is a circular area or a square area.

According to another exemplary embodiment of the present disclosure, the plurality of piezoelectric sensors are symmetrically arranged at a boundary line of the specified area around a geometric center of the specified area.

20 According to another exemplary embodiment of the present disclosure, in a plane view, the boundary line of the specified area passes through the geometric center of each piezoelectric sensor.

According to another exemplary embodiment of the present disclosure, when the controller detects that all output signals firstly output from the plurality of signal processing circuits are the first DC voltage digital signals, the controller determines that the knock event is occurred within the specified area on the touch panel.

30 According to another exemplary embodiment of the present disclosure, the piezoelectric sensors are arranged symmetrically at the edge of the touch panel around the geometric center of the specified area, so as to shield and hide the piezoelectric sensors by a mounting frame located at the edge of the touch panel.

According to another exemplary embodiment of the present disclosure, the controller is adapted to calculate a first time difference between an end time and a start time of the detected first DC voltage digital signal, calculate a second time difference between the start time of the detected first DC voltage digital signal and a start time of the second DC voltage digital signal detected just after the detected first DC voltage digital signal, and determine whether the knock event is a correct human finger knock event based on the calculated first time difference and the calculated second time difference.

According to another exemplary embodiment of the present disclosure, if a difference between the second time difference and the first time difference is within a first threshold range, then the controller determines that the knock event is a correct human finger knock event.

5 According to another exemplary embodiment of the present disclosure, if a difference between the second time difference and the first time difference exceeds the first threshold range, then the controller determines that the knock event is not a correct human finger knock event.

10 According to another exemplary embodiment of the present disclosure, the first threshold range is 300 μ s~1400 μ s.

According to another exemplary embodiment of the present disclosure, in a condition where the controller determines that the knock event is a correct human finger knock event, if the first DC voltage digital signal is detected by the controller only once, then the controller determines that the knock event is a single-click event.

15 According to another exemplary embodiment of the present disclosure, in a condition where the controller determines that the knock event is a correct human finger knock event, if the first DC voltage digital signal is detected by the controller twice and a time interval between two adjacent first DC voltage digital signals detected by the controller is within a second threshold range, the controller determines that the knock event is a double-click event.

20 According to another exemplary embodiment of the present disclosure, the second threshold range is 200ms~500ms.

25 According to another exemplary embodiment of the present disclosure, the touch panel is adapted to be mounted on a support body, the touch detection device further comprises an acoustic wave absorbing material provided between the touch panel and the support body for acoustically isolating the touch panel from the support body, so as to prevent sound waves generated on the support body from being transmitted to the touch panel.

30 According to another exemplary embodiment of the present disclosure, the support body is a housing, the touch panel is embedded in an opening of the support body, and the acoustic wave absorbing material is arranged at the periphery edge of the touch panel.

According to another exemplary embodiment of the present disclosure, the touch panel is supported on a surface of the support body, and the acoustic wave absorbing material is provided on the bottom of the touch panel.

35 According to another exemplary embodiment of the present disclosure, the touch panel is a circular panel, a square panel or a curved surface panel.

According to another exemplary embodiment of the present disclosure, the touch panel is made of glass, stainless steel or wood.

According to another exemplary embodiment of the present disclosure, the

piezoelectric sensor is a piezoelectric thin film sensor or a piezoelectric ceramic sensor.

In the above various exemplary embodiments of the present disclosure, the touch detection device may conveniently and accurately identify whether the knock event applied on the touch panel is occurred within a specified area on the touch panel. In addition, the configuration of the touch detection device is very simple, and the cost of it is low.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present disclosure will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

Fig.1 is an illustrative view of a touch detection device according to an embodiment of the present disclosure;

Fig.2 is an illustrative view of a touch detection device according to another embodiment of the present disclosure;

Fig.3 shows a functional block diagram of a control circuit board of a touch detection device according to an embodiment of the present disclosure;

Fig.4 is an illustrative view of a signal processing circuit of the control circuit board in Fig. 3; and

Fig.5 shows an input signal from a piezoelectric sensor to the signal processing circuit and an output signal processed by the signal processing circuit.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Exemplary embodiments of the present disclosure will be described hereinafter in detail with reference to the attached drawings, wherein the like reference numerals refer to the like elements. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiment set forth herein; rather, these embodiments are provided so that the present disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art.

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

According to a general concept of the present disclosure, there is provided a touch detection device, comprising: a touch panel; a plurality of piezoelectric sensors mounted on the touch panel and adapted to detect a knock or touching event applied to the touch panel;

and a control circuit board electrically communicated with the piezoelectric sensors. The control circuit board comprising: a plurality of signal processing circuits connected to the plurality of piezoelectric sensors, respectively, and configured to process the detection signals output from the plurality of piezoelectric sensors, respectively; and a controller adapted to determine whether the knock event is occurred within a specified area on the touch panel based on the processed detection signals.

Fig.1 is an illustrative view of a touch detection device according to an embodiment of the present disclosure.

As shown in Fig.1, in an embodiment, the touch detection device mainly comprises a touch panel 10, a plurality of piezoelectric sensors S1, S2, S3, S4, and a control circuit board 200.

As shown in Fig.1, in an embodiment, the plurality of piezoelectric sensors S1, S2, S3, S4 are mounted on the touch panel 10 and adapted to detect a knock or touching event applied to the touch panel 10. The control circuit board 200 is electrically communicated with the piezoelectric sensors S1, S2, S3, S4. For example, the piezoelectric sensors S1, S2, S3, S4 are connected to the control circuit board 200 by wires.

As shown in Fig.1, in an embodiment, the piezoelectric sensor 100 is a piezoelectric thin film sensor. However, the present disclosure is not limited to this, the piezoelectric sensor may be any other type of piezoelectric sensor made of any suitable piezoelectric induction material. For example, the piezoelectric sensor 100 may be a piezoelectric ceramic sensor made of piezoelectric ceramic.

Fig.3 shows a functional block diagram of a control circuit board of a touch detection device according to an embodiment of the present disclosure; Fig.4 is an illustrative view of a signal processing circuit of the control circuit board in Fig. 3.

As shown in Figs.3-4, in an embodiment, the control circuit board 200 mainly comprises a plurality of signal processing circuits 210 and a controller 220. The plurality of signal processing circuits 210 are electrically connected to the plurality of piezoelectric sensors S1, S2, S3, S4, respectively, and configured to process the detection signals output from the plurality of piezoelectric sensors S1, S2, S3, S4, respectively. The controller 220 is adapted to determine whether the knock event is occurred within a specified area A on the touch panel 10 based on the processed detection signals.

As shown in Figs.3-4, in an embodiment, each of the signal processing circuits 210 comprises: a filter 211, an amplifier 212, and a comparator 2131, 2132. The filter 211 is configured to filter out noise signals that are not satisfied with a predetermined condition from the detection signal. For example, the filter 211 may filter out high-frequency vibration signals with a frequency higher than 2 KHz, because finger knocking frequency is usually below 2 KHz.

As shown in Figs.3-4, in an embodiment, the amplifier 212 is configured to amplify the

filtered detection signal to a desired range. The comparator 2131, 2132 comprises an upper-threshold comparator 2131 with a predetermined upper-threshold voltage Ref1 and a lower-threshold comparator 2132 with a predetermined lower-threshold voltage Ref2. The upper-threshold comparator 2131 is configured to process the amplified detection signal into a first DC voltage digital signal P1, and the lower-threshold comparator 2132 is configured to process the amplified detection signal into a second DC voltage digital signal P2.

As shown in Figs.1 and 3-4, in an embodiment, the controller 220 is configured to determine whether the knock event is occurred within the specified area A on the touch panel 10 based on the first DC voltage digital signals P1 and the second DC voltage digital signals P2 output from the plurality of signal processing circuits 210.

Fig.5 shows an input signal from a piezoelectric sensor to the signal processing circuit and an output signal processed by the signal processing circuit.

As shown in Figs.3-5, in an embodiment, the first DC voltage digital signal P1 output from the upper-threshold comparator 2131 corresponds to the negative half period of the detection signal output from the piezoelectric sensor 100. The second DC voltage digital signal P2 output from the lower-threshold comparator 2132 corresponds to the positive half period of the detection signal output from the piezoelectric sensor 100.

As shown in Figs.1 and 3-5, in an embodiment, the specified area A is a circular area. But the present disclosure is not limited to this, for example, the specified area A may be a square area.

As shown in Figs.1 and 3-5, in an embodiment, the plurality of piezoelectric sensors S1, S2, S3, S4 are symmetrically arranged on a boundary line of the specified area A around a geometric center of the specified area A.

As shown in Figs.1 and 3-5, in an embodiment, in a plane view, the boundary line of the specified area A passes through the geometric center of each of the piezoelectric sensors S1, S2, S3, S4.

As shown in Figs.1 and 3-5, in an embodiment, when the controller 220 detects that all output signals firstly output from the plurality of signal processing circuits 210 are the first DC voltage digital signals P1, the controller 220 determines that the knock event is occurred within the specified area A on the touch panel 10.

As shown in Figs.1 and 3-5, in an embodiment, when the controller 220 detects that not all output signals firstly output from the plurality of signal processing circuits 210 are the first DC voltage digital signals P1, the controller 220 determines that the knock event is occurred outside the specified area A on the touch panel 10.

Fig.2 is an illustrative view of a touch detection device according to another embodiment of the present disclosure.

As shown in Fig.2, in an embodiment, the piezoelectric sensors S1, S2, S3, S4 are arranged symmetrically on the edge of the touch panel 10 around the geometric center of the

specified area A. The piezoelectric sensors S1, S2, S3, S4 are shielded and hidden by a mounting frame located at the edge of the touch panel 10. In this way, it may improve the aesthetics of touch detection device.

As shown in Figs.2-5, in an embodiment, when the controller 220 detects that all output signals firstly output from the plurality of signal processing circuits 210 are the first DC voltage digital signals P1 or that all output signals firstly output from the plurality of signal processing circuits 210 are the second DC voltage digital signals P2, the controller 220 determines that the knock event is occurred within the specified area A on the touch panel 10.

As shown in Figs.2-5, in an embodiment, when the controller 220 detects that not all output signals firstly output from the plurality of signal processing circuits 210 are the first DC voltage digital signals P1 or that not all output signals firstly output from the plurality of signal processing circuits 210 are the second DC voltage digital signals P2, the controller 220 determines that the knock event is occurred outside the specified area A on the touch panel 10.

As shown in Figs.1-5, in an embodiment, the controller 220 is adapted to calculate a first time difference t1 between an end time tc2 and a start time tc1 of the detected first DC voltage digital signal P1, calculate a second time difference t2 between the start time tc1 of the detected first DC voltage digital signal P1 and a start time tc3 of the second DC voltage digital signal P2 detected just after the detected first DC voltage digital signal P1, and determine whether the knock event is a correct human finger knock event based on the calculated first time difference t1 and the calculated second time difference t2.

As shown in Figs.1-5, in an embodiment, if a difference between the second time difference t2 and the first time difference t1 is within a first threshold range, then the controller 220 determines that the knock event is a correct human finger knock event.

As shown in Figs.1-5, in an embodiment, if a difference between the second time difference t2 and the first time difference t1 exceeds the first threshold range, then the controller 220 determines that the knock event is not a correct human finger knock event.

As shown in Figs.1-5, in an embodiment, the first threshold range is 300 μ s~1400 μ s.

As shown in Figs.1-5, in an embodiment, in a condition where the controller 220 determines that the knock event is a correct human finger knock event, if the first DC voltage digital signal P1 is detected by the controller 220 only once, then the controller 220 determines that the knock event is a single-click event.

As shown in Figs.1-5, in an embodiment, in a condition where the controller 220 determines that the knock event is a correct human finger knock event, if the first DC voltage digital signal P1 is detected by the controller 220 twice and a time interval between two adjacent first DC voltage digital signals P1 detected by the controller 220 is within a second threshold range, the controller 220 determines that the knock event is a double-click

event.

As shown in Figs.1-5, in an embodiment, the second threshold range is 200ms~500ms.

As shown in Figs.1-2, in an embodiment, the touch panel 10 is adapted to be mounted on a support body 20, and the touch detection device further comprises an acoustic wave absorbing material 30 adapted to be provided between the touch panel 10 and the support body 20 for acoustically isolating the touch panel 10 from the support body 20, so as to prevent sound waves generated on the support body 20 from being transmitted to the touch panel 10.

As shown in Figs.1-2, in an embodiment, the support body 20 is formed as a housing, the touch panel 10 is embedded in an opening of the support body 20, and the acoustic wave absorbing material 30 is arranged at the periphery edge of the touch panel 10.

However, the present disclosure is not limited to illustrated embodiments, for example, in another embodiment, the touch panel 10 may be supported on a surface of the support body 20, and the acoustic wave absorbing material 30 may be provided on the bottom of the touch panel 10.

As shown in Figs.1-2, in an embodiment, the touch panel 10 comprises a circular panel. But the present disclosure is not limited to this, the touch panel 10 may comprise a square panel or a curved surface panel.

As shown in Figs.1-2, in an embodiment, the touch panel 10 is made of glass, stainless steel or wood.

The present application provides a sensor and a panel adapted to detect knock signals generated within the specified area based on piezoelectric material such as piezoelectric thin film and piezoelectric ceramic. A piece of piezoelectric material is mounted on a rigid panel. The shape of the panel may have a flat surface or any arbitrary three-dimensional surface. Sound absorbing material such as sound-absorbing foam or rubber is provided around the rigid panel to isolate the sound. When the finger knocks the panel, the sound wave (mechanical wave) generated by knocking is propagated along the hard panel to position where the piezoelectric material is located. The piezoelectric material produces piezoelectric effect due to vibration, and generates charges on the upper and lower surface of the piezoelectric material. Since the vibration occurs in a common region of the piezoelectric material, the direction of the electric charges generated by piezoelectric material should be the same and the phase deviation thereof should be small. The generated voltage signal is amplified and filtered by a corresponding circuit, and then is processed by a specific algorithm to obtain a desired signal. When a region outside the panel is knocked by the finger, the mechanical vibration of the panel is not transmitted to the location of the piezoelectric material because the sound-absorbing material prevents the mechanical vibration from being transmitted to the piezoelectric material, so the false trigger may be avoided.

In the present application, the piezoelectric sensor may be easily and directly mounted on a hard surface such as glass, mirror, stainless steel, and wood by surface mount Technology (SMT). Thereby, it has great cost advantages. In addition, it has no restrictions on the shape and size of the panel, and the piezoelectric sensor may be mounted on any part of the panel, and has fewer restrictions and challenges on the design of the device, for example, household appliances.

In the present application, the knock or touching signal transmitted by the piezoelectric thin film sensors, which are arranged in an array, is processed by a hardware circuit into a digital signal related to the knock touching force and the knock or touching frequency, and then the knock or touching signal is filtered through software algorithm to determine whether it is a human finger knock event or a double-click event. Thereby, it may be very intelligent to complete the detection of human knock or touching, and may be used for different user experiences of household appliances.

It should be appreciated for those skilled in this art that the above embodiments are intended to be illustrated, and not restrictive. For example, many modifications may be made to the above embodiments by those skilled in this art, and various features described in different embodiments may be freely combined with each other without conflicting in configuration or principle.

Although several exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that various changes or modifications may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

As used herein, an element recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments "comprising" or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

What is claimed is,

1. A touch detection device, comprising:

a touch panel (10);

5 a plurality of piezoelectric sensors (S1, S2, S3, S4) mounted on the touch panel (10) and adapted to detect a knock event applied to the touch panel (10); and

a control circuit board (200) electrically communicated with the piezoelectric sensors (S1, S2, S3, S4), and comprising:

10 a plurality of signal processing circuits (210) electrically connected to the plurality of piezoelectric sensors (S1, S2, S3, S4), respectively, and configured to process the detection signals output from the plurality of piezoelectric sensors (S1, S2, S3, S4), respectively; and

a controller (220) adapted to determine whether the knock event is occurred within a specified area (A) on the touch panel (10) based on the processed detection signals.

15

2. The touch detection device according to claim 1, wherein each of the signal processing circuits (210) comprising:

a filter (211) configured to filter out noise signals that are not satisfied with a predetermined condition from the detection signal;

20 an amplifier (212) configured to amplify the filtered detection signal to a desired range; and

a comparator (2131, 2132) comprising an upper-threshold comparator (2131) with a predetermined upper-threshold voltage (Ref1) and a lower-threshold comparator (2132) with a predetermined lower-threshold voltage (Ref2) to process the amplified detection signal
25 into a first DC voltage digital signal (P1) and a second DC voltage digital signal (P2).

3. The touch detection device according to claim 2,

wherein the controller (220) is configured to determine whether the knock event is occurred within the specified area (A) on the touch panel (10) based on the first DC voltage digital signals (P1) and the second DC voltage digital signals (P2) output from the plurality
30 of signal processing circuits (210).

4. The touch detection device according to claim 3,

wherein the first DC voltage digital signal (P1) output from the upper-threshold
35 comparator (2131) corresponds to the negative half period of the detection signal output from the piezoelectric sensor (100); and

wherein the second DC voltage digital signal (P2) output from the lower-threshold comparator (2132) corresponds to the positive half period of the detection signal output

from the piezoelectric sensor (100).

5. The touch detection device according to claim 4,

wherein when the controller (220) detects that all output signals firstly output from the plurality of signal processing circuits (210) are the first DC voltage digital signals (P1) or that all output signals firstly output from the plurality of signal processing circuits (210) are the second DC voltage digital signals (P2), the controller (220) determines that the knock event is occurred within the specified area (A) on the touch panel (10).

10 6. The touch detection device according to claim 4 or 5,

wherein when the controller (220) detects that not all output signals firstly output from the plurality of signal processing circuits (210) are the first DC voltage digital signals (P1) or that not all output signals firstly output from the plurality of signal processing circuits (210) are the second DC voltage digital signals (P2), the controller (220) determines that the knock event is occurred outside the specified area (A) on the touch panel (10).

7. The touch detection device according to any one of claim 1-6, wherein the specified area (A) comprises a circular area or a square area.

20 8. The touch detection device according to claim 7,

wherein the plurality of piezoelectric sensors (S1, S2, S3, S4) are symmetrically arranged at a boundary line of the specified area (A) around a geometric center of the specified area (A).

25 9. The touch detection device according to claim 8,

wherein in a plane view, the boundary line of the specified area (A) passes through the geometric center of each piezoelectric sensor (S1, S2, S3, S4).

10. The touch detection device according to claim 9,

30 wherein when the controller (220) detects that all output signals firstly output from the plurality of signal processing circuits (210) are the first DC voltage digital signals (P1), the controller (220) determines that the knock event is occurred within the specified area (A) on the touch panel (10).

35 11. The touch detection device according to any one of claims 7-10,

wherein the piezoelectric sensors (S1, S2, S3, S4) are arranged symmetrically at the edge of the touch panel (10) around the geometric center of the specified area (A), so as to shield and hide the piezoelectric sensors (S1, S2, S3, S4) by a mounting frame located at the

edge of the touch panel (10).

12. The touch detection device according to any one of claims 5-11,

wherein the controller (220) is adapted to calculate a first time difference (t1) between
5 an end time (tc2) and a start time (tc1) of the detected first DC voltage digital signal (P1),
calculate a second time difference (t2) between the start time (tc1) of the detected first DC
voltage digital signal (P1) and a start time (tc3) of the second DC voltage digital signal (P2)
detected just after the detected first DC voltage digital signal (P1), and determine whether
the knock event is a correct human finger knock event based on the calculated first time
10 difference (t1) and the calculated second time difference (t2).

13. The touch detection device according to claim 12,

wherein if a difference between the second time difference (t2) and the first time
difference (t1) is within a first threshold range, then the controller (220) determines that the
15 knock event is a correct human finger knock event.

14. The touch detection device according to claim 13,

wherein if a difference between the second time difference (t2) and the first time
difference (t1) exceeds the first threshold range, then the controller (220) determines that the
20 knock event is not a correct human finger knock event.

15. The touch detection device according to claim 14, wherein the first threshold range
is 300 μ s~1400 μ s.

16. The touch detection device according to any one of claims 13-15,

wherein in a condition where the controller (220) determines that the knock event is a
correct human finger knock event, if the first DC voltage digital signal (P1) is detected by
the controller (220) only once, then the controller (220) determines that the knock event is a
single-click event.

17. The touch detection device according to any one of claims 13-15,

wherein in a condition where the controller (220) determines that the knock event is a
correct human finger knock event, if the first DC voltage digital signal (P1) is detected by
the controller (220) twice and a time interval between two adjacent first DC voltage digital
35 signals (P1) detected by the controller (220) is within a second threshold range, the
controller (220) determines that the knock event is a double-click event.

18. The touch detection device according to claim 17, wherein the second threshold

range is 200ms~500ms.

19. The touch detection device according to any one of claims 1-18,

5 wherein the touch panel (10) is adapted to be mounted on a support body (20), the touch detection device further comprises an acoustic wave absorbing material (30) provided between the touch panel (10) and the support body (20) for acoustically isolating the touch panel (10) from the support body (20), so as to prevent sound waves generated on the support body (20) from being transmitted to the touch panel (10).

10 20. The touch detection device according to claim 19,

wherein the support body (20) is formed as a housing, the touch panel (10) is embedded in an opening of the support body (20), and the acoustic wave absorbing material (30) is arranged at the periphery edge of the touch panel (10).

15 21. The touch detection device according to claim 19,

wherein the touch panel (10) is supported on a surface of the support body (20), and the acoustic wave absorbing material (30) is provided on the bottom of the touch panel (10).

22. The touch detection device according to any one of claims 1-21, wherein the touch

20 panel (10) comprises a circular panel, a square panel or a curved surface panel.

23. The touch detection device according to any one of claims 1-22, wherein the touch panel (10) is made of glass, stainless steel or wood.

25 24. The touch detection device according to any one of claims 1-23, wherein the piezoelectric sensor (100) comprises a piezoelectric thin film sensor or a piezoelectric ceramic sensor.

30

DRAWINGS

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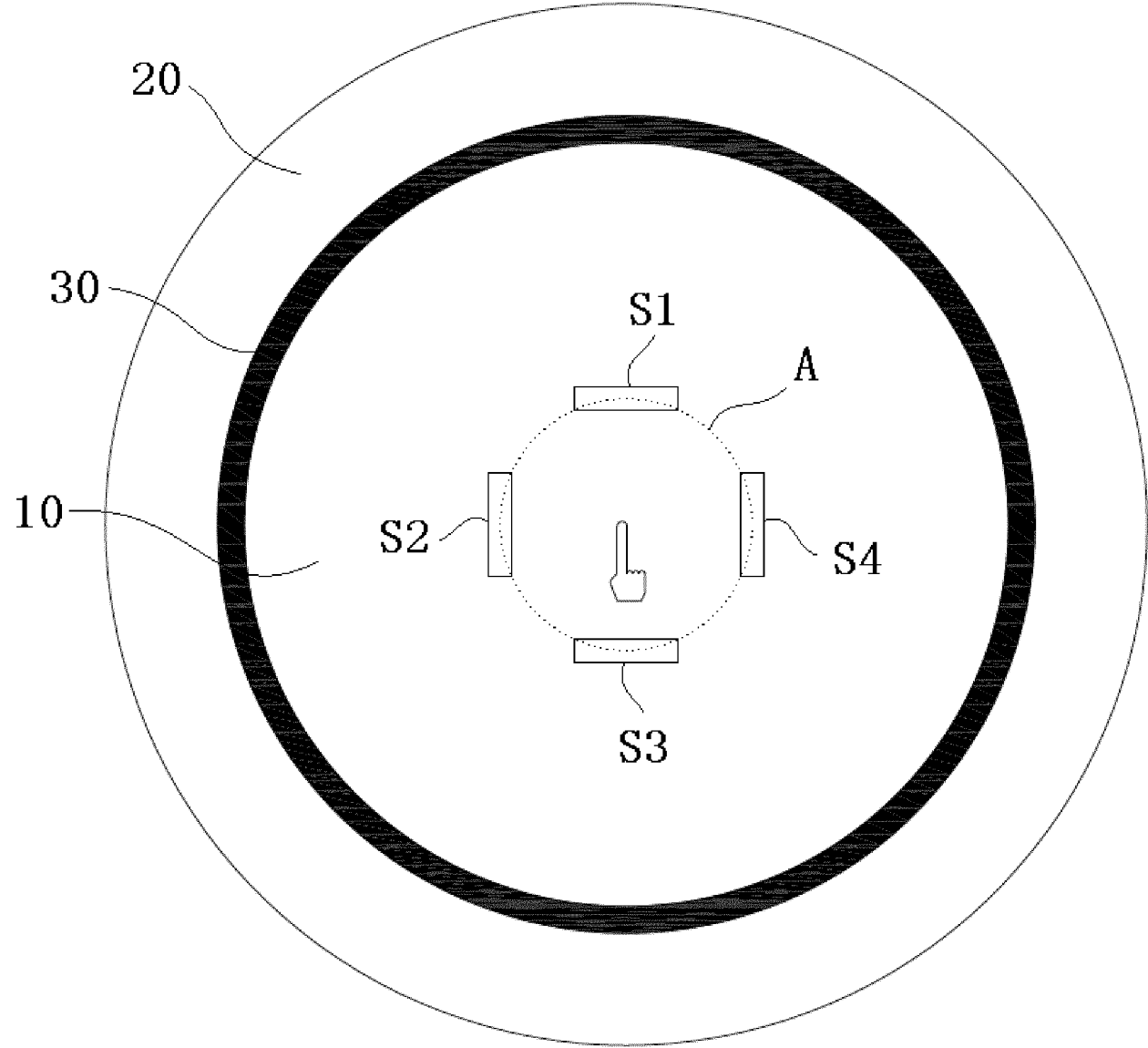


Fig.1

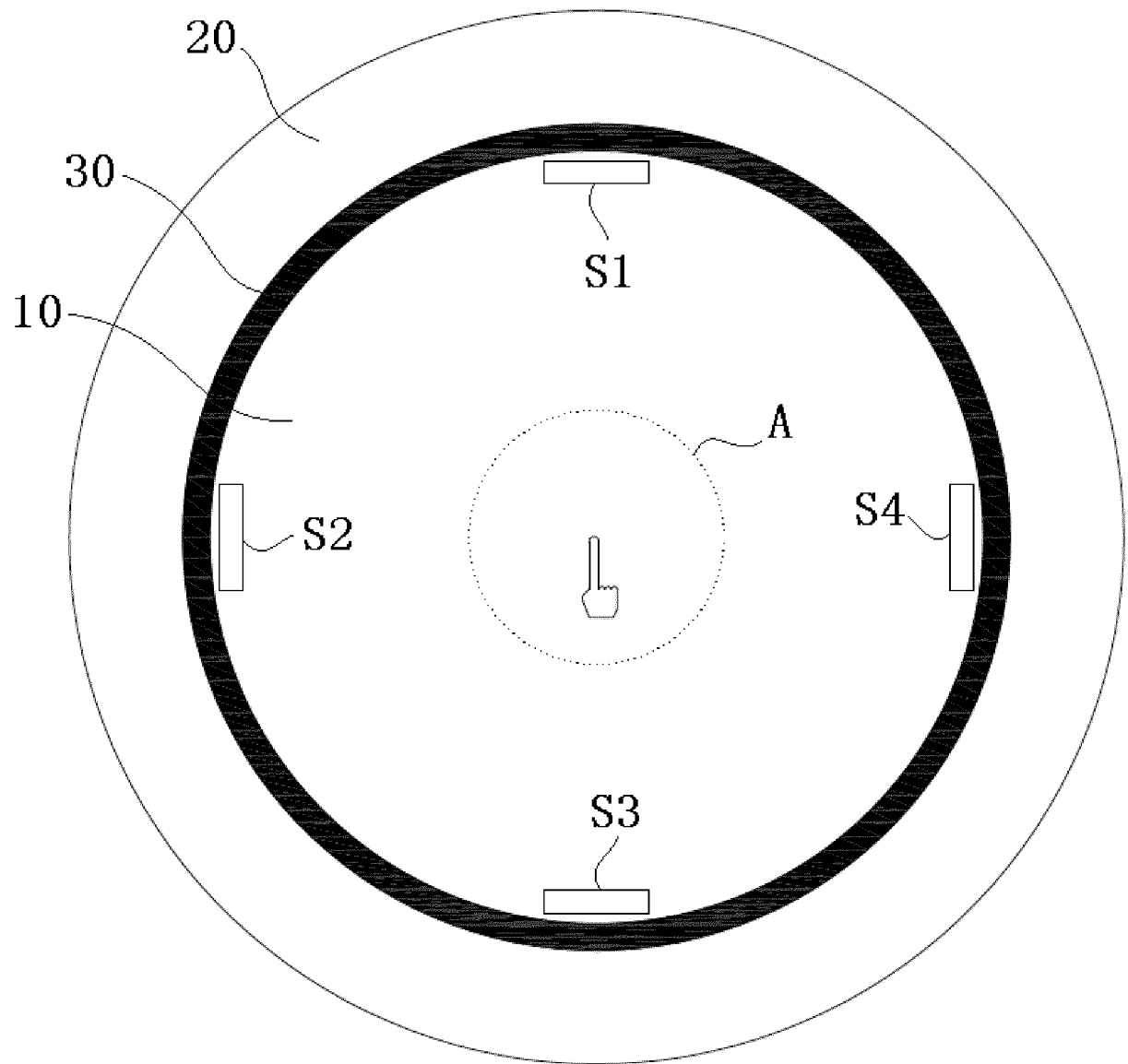


Fig.2

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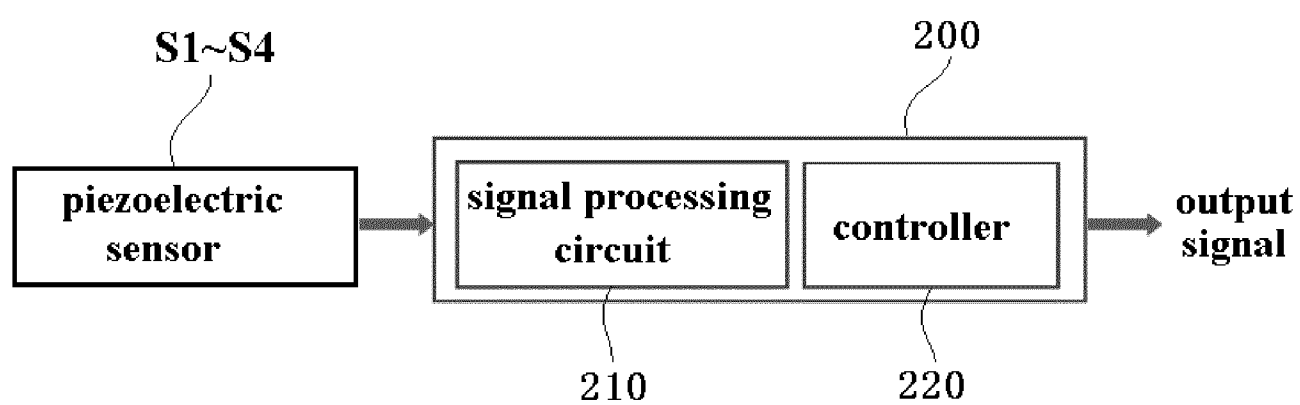


Fig.3

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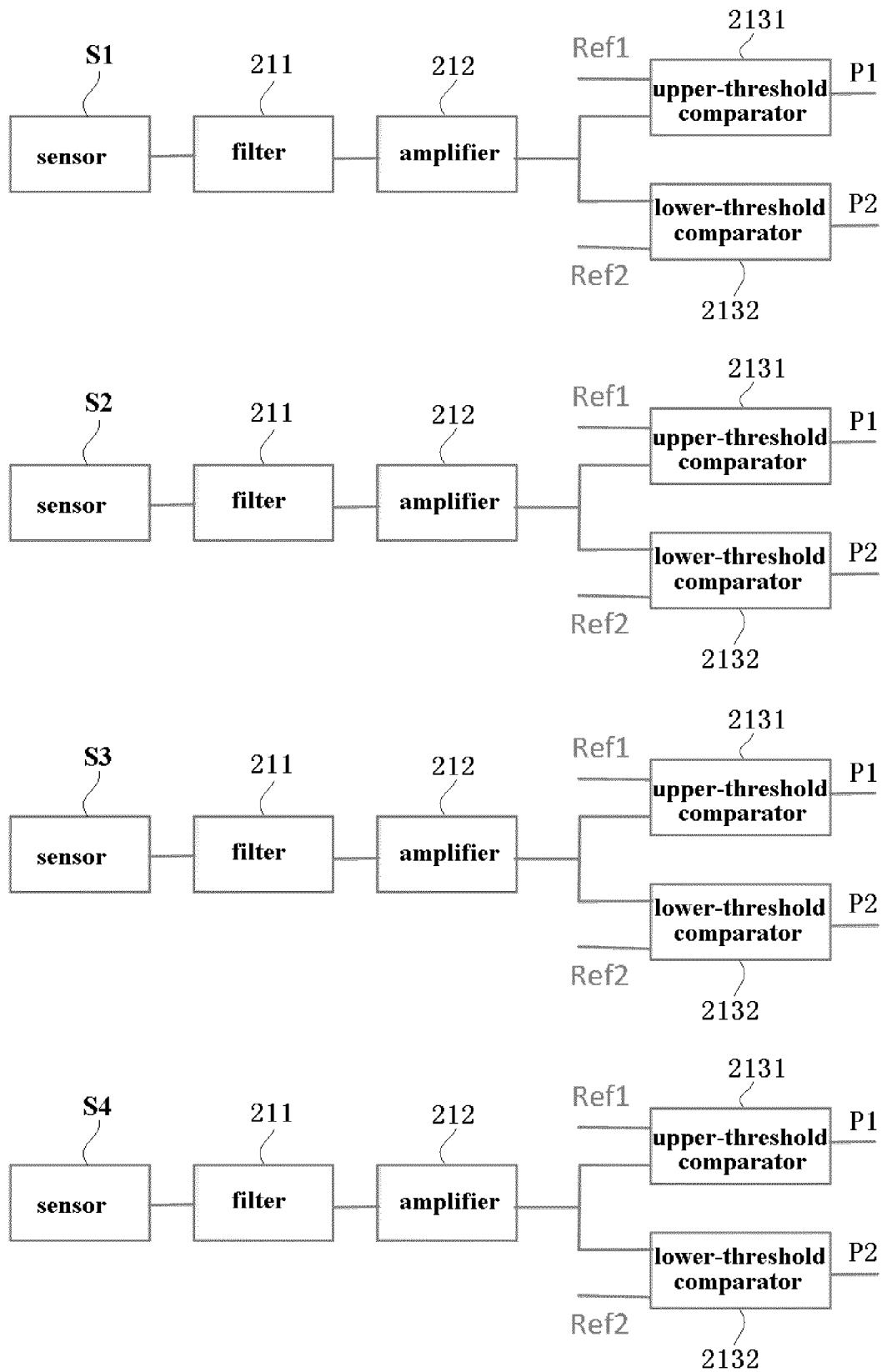


Fig.4

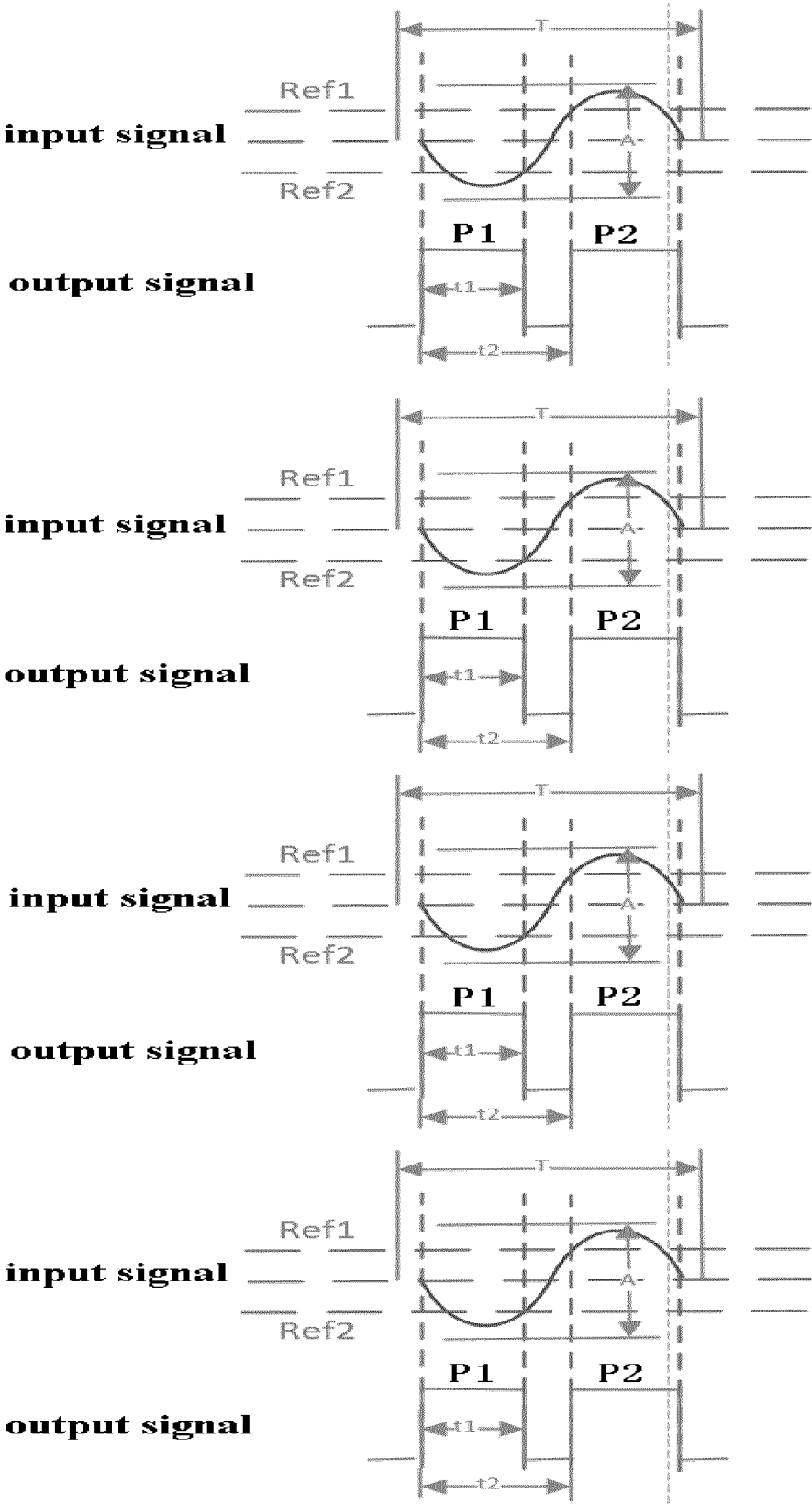


Fig.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/079222

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/041
ADD.

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)
G06F

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

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

EPO-Internal, WPI Data

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X	US 2006/232558 A1 (CHIEN HUAN-WEN [TW]) 19 October 2006 (2006-10-19) abstract paragraph [0009] - paragraph [0035]; figures 2-6	1-24
X	WO 2007/035896 A2 (QUALCOMM INC [US]; SHEYNBLAT LEONID [US]; GUM ARNOLD J [US]) 29 March 2007 (2007-03-29) paragraph [0019] - paragraph [0030] paragraph [0034] - paragraph [0037]; figures 1-2,4	1-24
	-/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

10/12/2019

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/079222

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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International application No

PCT/EP2019/079222

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