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(54) Title: CAPACITANCE DETECTING CIRCUIT

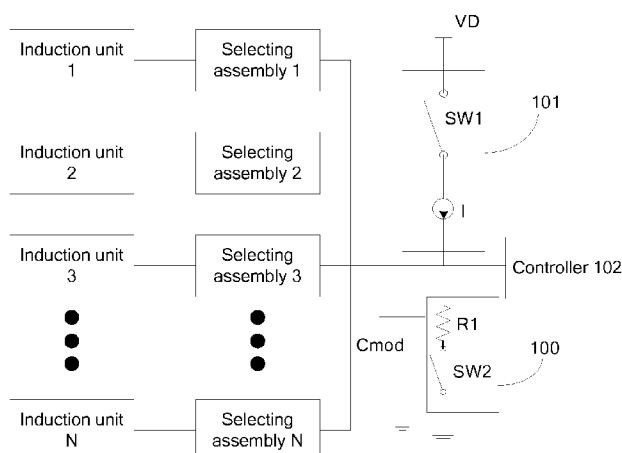


Fig. 1

(57) **Abstract:** A capacitance detecting circuit is provided, comprising: N induction units; a transferring capacitor configured to transfer charges to a capacitor of a scanned induction unit, and a second terminal of the transferring capacitor is grounded; a charging module (101) configured to charge the transferring capacitor, and a second terminal of the charging module (101) is connected with a first power supply; a discharging module (100) configured to discharge the transferring capacitor and comprising a first resistor and a second switch, a second terminal of the discharging module (100) is grounded; a controller connected with the charging module (101), the transferring capacitor and the discharging module respectively, and configured to control the second switch to switch on when a voltage of the transferring capacitor is larger than a preset threshold voltage, to update a count value and to detect a touch on the N induction units according to the count value.

CAPACITANCE DETECTING CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to, and benefits of Chinese Patent Application Serial No.
5 201210585884.2, filed with the State Intellectual Property Office of P. R. C. on December 30,
2012, the entire content of which is incorporated herein by reference.

FIELD

Exemplary embodiments of the present disclosure relate generally to a circuit design field,
10 and more particularly to a capacitance detecting circuit.

BACKGROUND

Presently, a touch screen with advantages of easy and convenient operation and humanization
is widely used in various kinds of electronic products like a mobile phone, a PDA (personal digital
15 assistant), a GPS (global position system), a PMP (MP3, MP4, etc.) and a tablet personal
computer.

Conventionally, an induction unit in the touch screen is judged whether to be touched or not
by detecting a self-capacitance thereof, so it becomes more important to accurately detect the
self-capacitance generated by the induction unit in the touch screen when the induction unit is
20 touched.

However, a conventional method for detecting a capacitance has a disadvantage of low
detection accuracy. When detecting the capacitance generated by touching the induction unit, an
error occurs because of an existence of a mutual-capacitance, thus decreasing the detection
accuracy, and therefore it is difficult to correctly judge whether the induction unit is touched or
25 not.

SUMMARY

Embodiments of the present disclosure seek to solve at least one of the problems existing in
the related art to at least some extent.

30 According to embodiments of the present disclosure, a capacitance detecting circuit is
provided. The capacitance detecting circuit comprises: N induction units, where N is an integer

larger than or equal to 1; a transferring capacitor configured to transfer charges to a capacitor of a scanned induction unit among the N induction units, wherein a first terminal of the transferring capacitor is connected with the N induction units respectively, and a second terminal of the transferring capacitor is grounded; a charging module configured to charge the transferring capacitor, wherein a first terminal of the charging module is connected with the first terminal of the transferring capacitor, and a second terminal of the charging module is connected with a first power supply; a discharging module configured to discharge the transferring capacitor and comprising a first resistor and a second switch, wherein a first terminal of the discharging module is connected with the first terminal of the charging module and the first terminal of the transferring capacitor respectively, a second terminal of the discharging module is grounded; a controller connected with the charging module, the transferring capacitor and the discharging module respectively, and configured to control the second switch to switch on when a voltage of the transferring capacitor is larger than a preset threshold voltage, to update a count value and to detect a touch on the N induction units according to the count value.

With the capacitance detecting circuit, when detecting the capacitance generated by touching the induction unit, an influence of a mutual-capacitance may be eliminated, thus improving a detection accuracy, thereby the induction unit can be judged correctly whether to be touched or not.

Additional aspects and advantages of embodiments of present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of embodiments of the present disclosure will become apparent and more readily appreciated from the following descriptions made with reference to the drawings, in which:

Fig. 1 is a schematic diagram of a capacitance detecting circuit according to an embodiment of the present disclosure;

Fig. 2 is a schematic circuit diagram of the capacitance detecting circuit according to an embodiment of the present disclosure;

Fig. 3 is a schematic circuit diagram of the capacitance detecting circuit according to an

example of the present disclosure;

Fig. 4 is a wave chart of switch controlling signals of the capacitance detecting circuit according to an embodiment of the present disclosure;

Fig. 5 is a wave chart of switch controlling signals of the capacitance detecting circuit according to another embodiment of the present disclosure.

DETAILED DESCRIPTION

Reference will be made in detail to embodiments of the present disclosure. The embodiments described herein with reference to drawings are explanatory, illustrative, and used to generally understand the present disclosure. The embodiments shall not be construed to limit the present disclosure. The same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions.

In the description, terms concerning attachments, coupling and the like, such as “connected” and “interconnected”, refer to a relationship in which structures are secured or attached to one another through mechanical or electrical connection, or directly or indirectly through intervening structures, unless expressly described otherwise.

In addition, terms such as “first” and “second” are used herein for purposes of description and are not intended to indicate or imply relative importance or significance.

As shown in Fig. 1, according to an embodiment of the present disclosure, a capacitance detecting circuit is provided. The capacitance detecting circuit comprises N induction units (1, 2, 3... N), a transferring capacitor C_{mod} , a charging module 101, a controller 102 and a discharging module 100.

When each induction unit is touched, a capacitance thereof is changed. N is an integer larger than or equal to 1. In one embodiment, the capacitance detecting circuit may detect a plurality of induction units simultaneously.

As shown in Fig. 1, the transferring capacitor C_{mod} is configured to transfer its charges to a self-capacitor of a scanned induction unit among the N induction units (1, 2, 3... N). A first terminal of the transferring capacitor is connected with first terminals of the N induction units respectively, a second terminal of the transferring capacitor is grounded, and second terminals of the N induction units are commonly grounded. In general, when the induction unit is touched, a capacitance thereof may be increased. For example, when it is scanned that induction units 1, 2, 3

among the N induction units are touched, a self-capacitance of each of the scanned induction units 1, 2, 3 is changed (for example increased), and the transferring capacitor Cmod transfers its charges to the self-capacitor of each of the scanned induction units 1, 2, 3 respectively, so as to pull down a voltage of the transferring capacitor Cmod.

5 The charging module 101 is configured to charge the transferring capacitor Cmod. A first terminal of the charging module 101 is connected with the first terminal of the transferring capacitor Cmod, and a second terminal of the charging module 101 is connected with a first power supply VD. The charging module 101 comprises a first switch SW1 and a current source I connected in series.

10 The discharging module 100 is configured to discharge the transferring capacitor Cmod and comprises a first resistor R1 and a second switch SW2. A first terminal of the discharging module 100 is connected with the first terminal of the charging module 101 and the first terminal of the transferring capacitor Cmod respectively, and a second terminal of the discharging module 100 is grounded.

15 A controller 102 is connected with the charging module 101, the transferring capacitor Cmod and the discharging module 100 respectively. The controller 102 is configured to control the second switch SW2 to switch off when a voltage of the transferring capacitor Cmod is larger than a preset threshold voltage Vth, to update a count value and to detect a touch on the N induction units according to the count value. That is to say, the controller 102 controls the second switch
20 SW2 to switch on when the voltage of the transferring capacitor Cmod is larger than the preset threshold voltage Vth; controls the second switch SW2 to switch off when the voltage of the transferring capacitor Cmod is smaller than the preset threshold voltage Vth; and updates a count value according to the touch on the induction unit so as to detect the touch on the N induction units.

25 Specifically, firstly, the controller 102 controls the first switch SW1 to switch on so as to make the charging module 101 charge the transferring capacitor Cmod. The controller 102 controls the second switch SW2 to switch on when the voltage of the transferring capacitor Cmod is larger than the preset threshold voltage Vth. The controller 102 controls the second switch SW2 to switch off when the voltage of the transferring capacitor Cmod is smaller than the preset threshold voltage
30 Vth. The voltage of the transferring capacitor Cmod is pulled down when the charges of the transferring capacitor Cmod are transferred to a scanned induction unit. The larger the capacitance

of the scanned induction unit is, the lower the voltage of the transferring capacitor C_{mod} is, so that the smaller the count value of a counter is, that is to say, the count value of the touched induction unit is smaller than that of a non-touched induction unit, thus detecting the touch on the N induction units according to the count value.

5 In one embodiment of the present disclosure, as shown in Fig. 1, the capacitance detecting circuit further comprises N selecting assemblies (1, 2, 3...N), in which each selecting assembly corresponds to one induction unit and is connected between the one induction unit and the transferring capacitor C_{mod} . Each selecting assembly controls to connect or disconnect a corresponding induction unit with the transferring capacitor C_{mod} .

10 In one embodiment of the present disclosure, the each selecting assembly comprises a third switch SW3 and a fourth switch SW4. The third switch SW3 is connected between the corresponding induction unit and the transferring capacitor C_{mod} . A first terminal of the fourth switch SW4 is connected with the corresponding induction unit and a second terminal of the fourth switch SW4 is grounded. The third switch SW3 and the fourth switch SW4 are switched on
15 alternately.

Moreover, as shown in Fig. 2, the each selecting assembly comprises a fifth switch SW5, a first terminal of the fifth switch SW5 is connected with the corresponding induction unit, a second terminal of the fifth switch SW5 is connected with a second power supply V_{TH} , and a voltage of the second power supply V_{TH} is the preset threshold voltage V_{th} . Of course, in another
20 embodiment of the present disclosure, the voltage of the second power supply V_{TH} may be other values.

Further, in one embodiment of the present disclosure, as shown in Fig. 2, the capacitance detecting circuit further comprises a pre-charging module 201 configured to pre-charge the transferring capacitor C_{mod} . A first terminal of the pre-charging module 201 is connected with the
25 first terminal of the transferring capacitor C_{mod} , and a second terminal of the pre-charging module 201 is connected with the first power supply V_D . The pre-charging module 201 comprises a sixth switch SW6 and a second resistor R2 connected in series. That is to say, the pre-charging module 201 pre-charges the transferring capacitor C_{mod} until the voltage of the transferring capacitor C_{mod} closely reaches the preset threshold V_{th} before charging the transferring capacitor C_{mod} .

30 Also as shown in Fig. 2, the capacitance detecting circuit further comprises a pre-discharging module 202 configured to pre-discharge the transferring capacitor C_{mod} before the pre-charging

module pre-charges the transferring capacitor. A first terminal of the pre-discharging module 202 is connected with the first terminal of the transferring capacitor C_{mod} , and a second terminal of the pre-discharging module 202 is grounded. The pre-discharging module 202 comprises a seventh switch SW7 and the pre-discharging module 202 pre-discharges the transferring capacitor C_{mod} by grounding a first terminal of the seventh switch SW7. In the embodiment, pre-charging and pre-discharging the transferring capacitor C_{mod} is to ensure that states of the transferring capacitor C_{mod} are same for each detection, thus increasing the detection accuracy.

In one embodiment of the present disclosure, as shown in Fig. 2, the controller comprises: a comparator CMP, a trigger DFF, a counter 206, a detector 203 and a first selector 204. A first input terminal of the comparator CMP is applied with the preset threshold voltage V_{th} and a second input terminal of the comparator CMP is connected with the first terminal of the transferring capacitor C_{mod} . An input terminal of the trigger DFF is connected with an output terminal of the comparator CMP for generating a triggering signal according to a comparison result from the comparator CMP. The trigger DFF further comprises a clock signal CNT_CLK input. An input terminal of the counter 206 is connected with an output terminal of the trigger DFF for counting according to the triggering signal. The detector 203 is connected with the counter 206 and configured to detect the touch on the N induction units according to the count value of the counter 206. An input terminal of the first selector 204 is connected with the output terminal of the trigger DFF for generating a first control signal according to the triggering signal. The first control signal is configured to control the discharging module 100 to discharge to the transferring capacitor C_{mod} .

In addition, the controller 102 further comprises a second selector 205. An input terminal of the second selector 205 is connected with the output terminal of the comparator CMP for generating a second control signal according to the comparison result. The second control signal is configured to control the pre-charging module 201 to pre-charge the transferring capacitor C_{mod} .

Specifically, as shown in Fig. 2, the first selector 204 is an AND gate, a first input terminal of the AND gate is connected with the output terminal of the trigger DFF, and a second input terminal of the AND gate is applied with a switch enable signal SWITCH EN. During the pre-charging and pre-discharging, the switch enable signal SWITCH EN is low to control the second switch SW2 of the discharging module 100 to switch off. During the detection after the pre-charging, the switch enable signal SWITCH EN is high, and a signal from an output terminal of the AND gate controls

the second switch SW2 of the discharging module 100 to switch on or switch off. The switch enable signal SWITCH EN returns to be low after the detection is completed. The second selector 205 is a NOR gate, a first input terminal of the NOR gate is connected with the output terminal of the comparator CMP, and a second input terminal of the NOR gate is applied with a pre-charging signal PRE_CHRG.

In an example, when there is only one induction unit in the capacitance detecting circuit, as shown in Fig. 3, a capacitance detection process can be described as follows.

Firstly, the seventh switch SW7 is switched on to pre-discharge the transferring capacitor Cmod; secondly, the seventh switch SW7 is switched off and the sixth switch SW6 is switched on, so that the first power supply VD pre-charges the transferring capacitor Cmod by the second resistance R2 until the voltage of the transferring capacitor Cmod closely reaches the preset threshold voltage Vth. The first switch SW1 keeps off during the pre-discharging and the pre-charging. The sixth switch SW6 and the seventh switch SW7 are switched off after the pre-charging is completed. At this time, the first switch SW1 is controlled to switch on so that the first power supply VD pre-charges the transferring capacitor Cmod via a current source I. When the voltage of the transferring capacitor Cmod is larger than a reference voltage of the comparator CMP (i.e., the preset threshold voltage Vth), the trigger DFF controls the second switch SW2 to switch on according to the result output from the comparator CMP, so that the transferring capacitor Cmod is discharged via the first resistance R1. When the voltage of the transferring capacitor Cmod is smaller than the preset threshold voltage Vth, an output of the comparator CMP is turned over and the trigger DFF controls the second switch SW2 to switch off according to the output result from the comparator CMP. During a charge transferring process of the transferring capacitor Cmod, the charges of the transferring capacitor Cmod are transferred to a capacitor Cx of the induction unit via the third switch SW3. When the third switch SW3 is switched off, the voltage of the transferring capacitor Cmod is pulled down to be smaller than the preset threshold voltage Vth, which enables the output of the comparator CMP to be turned over so as to switch off the second switch SW2. At this time, the transferring capacitor Cmod is charged via the current source I until the voltage thereof is larger than the preset threshold voltage Vth, which enables the output of the comparator CMP to be turned over to switch on the second switch SW2. The third switch SW3 and the fourth switch SW4 are controlled by a two-phase non-overlapped clock signal (that is, when the third switch SW3 is controlled to switch on, the fourth switch SW4 is controlled

to switch off; and when the third switch SW3 is controlled to switch off, the fourth switch SW4 is controlled to switch on), the charges on the capacitor Cx transferred from the transferring capacitor Cmod are discharged to the ground by the fourth switch SW4. The fifth switch is a synchronous switch. When the induction unit is being scanned, the fifth switch SW5 is kept off.

5 The capacitance of the capacitor Cx, the duty ratio of a rectangular wave output from the trigger DFF and the count value of the counter 206 when the induction unit is touched are different from those when the induction unit is not touched. When the detection is finished, the above-mentioned processes are repeated.

10 Therefore, the detector 203 may judge whether the induction unit is touched according to the count value of the counter. For example, it is assumed that, when the induction unit is not touched, the count value of the counter is 1000; and when the induction unit is touched, the count value of the counter is 500. Thus it may judge whether the induction unit is touched or not according to the count value of the counter.

15 In one embodiment of the present disclosure, a wave chart of switch controlling signals under a non-fullscreen synchronous mode is shown in Fig. 4, where a high level means that the switch is controlled to switch on, and a low level means that the switch is controlled to switch off. When an M^{th} induction unit is scanned the fifth switch SW5 of an M^{th} selecting assembly is controlled to switch off by the controller 102, the third switch SW3 and the fourth switch SW4 of the M^{th} selecting assembly are controlled to switch on alternately by the controller 102, and the third
20 switch SW3, the fourth switch SW4 and the fifth switch SW5 of other selecting assemblies except the M^{th} selecting assembly are controlled to switch off by the controller 102.

25 In another embodiment of the present disclosure, a wave chart of the switch controlling signals under a fullscreen synchronous mode is shown in Fig. 5, where the high level means that the switch is controlled to switch on, and the low level means that the switch is controlled to switch off. When an M^{th} induction-unit is scanned, the fifth switch SW5 of an M^{th} selecting assembly is controlled to switch off by the controller 102, the third switch SW3 and the fourth switch SW4 of the M^{th} selecting assembly are controlled to switch on alternately by the controller 102, the third
30 switch SW3 of other selecting assemblies except the M^{th} selecting assembly is controlled to switch off by the controller 102, and the fourth switch SW4 and the fifth switch SW5 of other selecting assemblies except the M^{th} selecting assembly are controlled to switch on alternately by the controller 102. That is to say, when the M^{th} induction unit is scanned under the fullscreen

synchronous mode, the fifth switch SW5 of a currently scanned induction unit is controlled to switch off, while the fifth switches SW5 and the third switches SW3 of other synchronous but non-scanned induction units have a same on-off state, that is, the third switch SW3 and the fourth switch SW4 of the scanned induction unit are switched on alternatively, and the fourth switches SW4 and the fifth switches SW5 of other non-scanned induction units are switched on alternatively. In this way, when the currently scanned induction unit (i.e., the M^{th} induction unit) is touched, the charges of the transferring capacitor C_{mod} is transferred to the capacitor (self-capacitor) C_x of the M^{th} induction unit via the third switch SW3 of the M^{th} selecting assembly. The capacitors C_x of the synchronous but non-scanned induction units are charged with a specified voltage via the corresponding fifth switches SW5. In the embodiment of the present disclosure, the specified voltage value is equal to the preset threshold voltage V_{th} . Therefore, the capacitance C_x of the current scanned induction unit and that of the synchronous but non-scanned induction units are charged with the preset threshold voltage V_{th} , and are also discharged to ground via the corresponding fourth switch SW4, so as to eliminate an influence of a mutual capacitance, thus improving the detection accuracy.

With the capacitance detecting circuit, when detecting the capacitance generated by touching the induction unit, an influence of a mutual-capacitance may be eliminated, thus improving a detection accuracy, thereby the induction unit can be judged correctly whether to be touched or not.

In addition, each function cell of the embodiments of the present disclosure may be integrated in a processing module, or these cells may be separate physical entities, or two or more cells are integrated in a processing module. The integrated module may be realized in a form of hardware or in a form of software function modules. When the integrated module is realized in a form of software function module and is sold or used as a standalone product, the integrated module may be stored in a computer readable storage medium.

The storage medium mentioned above may be read-only memories, magnetic disks or CD, etc.

Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that the above embodiments cannot be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from spirit, principles and scope of the present disclosure.

WHAT IS CLAIMED IS:

1. A capacitance detecting circuit, comprising:

N induction units, where N is an integer larger than or equal to 1;

5 a transferring capacitor configured to transfer charges to a capacitor of a scanned induction unit among the N induction units, wherein a first terminal of the transferring capacitor is connected with the N induction units respectively, and a second terminal of the transferring capacitor is grounded;

10 a charging module configured to charge the transferring capacitor, wherein a first terminal of the charging module is connected with the first terminal of the transferring capacitor, and a second terminal of the charging module is connected with a first power supply;

15 a discharging module configured to discharge the transferring capacitor and comprising a first resistor and a second switch, wherein a first terminal of the discharging module is connected with the first terminal of the charging module and the first terminal of the transferring capacitor respectively, a second terminal of the discharging module is grounded;

a controller connected with the charging module, the transferring capacitor and the discharging module respectively, and configured to control the second switch to switch on when a voltage of the transferring capacitor is larger than a preset threshold voltage, and to update a count value and to detect a touch on the N induction units according to the count value.

20 2. The capacitance detecting circuit of claim 1, wherein the charging module comprises a first switch and a current source connected in series.

3. The capacitance detecting circuit of claim 1 or 2, further comprising:

N selecting assemblies, wherein each selecting assembly corresponds to one induction unit and is connected between the one induction unit and the transferring capacitor.

25 4. The capacitance detecting circuit of claim 3, wherein the each selecting assembly comprises: a third switch connected between the one induction unit and the transferring capacitor, and a fourth switch with a first terminal connected with the one induction unit and a second terminal grounded,

in which the third switch and the fourth switch are switched on alternately.

30 5. The capacitance detecting circuit of claim 3 or 4, wherein the each selecting assembly comprises a fifth switch, a first terminal of the fifth switch is connected with the one induction unit, a second terminal of the fifth switch is connected with a second power supply, and a voltage of the second power supply is the preset threshold voltage.

6. The capacitance detecting circuit of any of claims 1-5, further comprising:

35 a pre-charging module configured to pre-charge the transferring capacitor, wherein a first

terminal of the pre-charging module is connected with the first terminal of the transferring capacitor, and a second terminal of the pre-charging module is connected with the first power supply.

7. The capacitance detecting circuit of claim 6, wherein the pre-charging module comprises a sixth switch and a second resistor connected in series.

8. The capacitance detecting circuit of any of claims 1-7, further comprising:
a pre-discharging module configured to pre-discharge the transferring capacitor before the pre-charging module pre-charges the transferring capacitor, wherein a first terminal of the pre-discharging module is connected with the first terminal of the transferring capacitor, and a second terminal of the pre-discharging module is grounded.

9. The capacitance detecting circuit of claim 8, wherein the pre-discharging module comprises a seventh switch.

10. The capacitance detecting circuit of any of claims 1-9, wherein the controller comprises:
a comparator with a first input terminal applied with the preset threshold voltage and a second input terminal connected with the first terminal of the transferring capacitor;

a trigger with an input terminal connected with an output terminal of the comparator, and configured to generate a triggering signal according to a comparison result from the comparator;

a counter with an input terminal connected with an output terminal of the trigger, and configured to count according to the triggering signal;

a detector connected with the counter and configured to detect the touch on the N induction units according to the count value of the counter; and

a first selector with an input terminal connected with the output terminal of the trigger, and configured to generate a first control signal according to the triggering signal, in which the first control signal is configured to control the discharging module.

11. The capacitance detecting circuit of claim 10, wherein the controller further comprises:
a second selector with an input terminal connected with the output terminal of the comparator, and configured to generate a second control signal according to the comparison result, in which the second control signal is configured to control the pre-charging module.

12. The capacitance detecting circuit of claim 10, wherein the first selector is an AND gate, a first input terminal of the AND gate is connected with the output terminal of the trigger, and a second input terminal of the AND gate is applied with a switch enable signal.

13. The capacitance detecting circuit of claim 11, wherein the second selector is a NOR gate, a first input terminal of the NOR gate is connected with the output terminal of the comparator, and a second input terminal of the NOR gate is applied with a pre-charging signal.

14. The capacitance detecting circuit of any of claims 3-13, wherein when an Mth induction

unit is scanned under a non-fullscreen synchronous mode, the fifth switch of an M^{th} selecting assembly is controlled to switch off by the controller, the third switch and the fourth switch of the M^{th} selecting assembly are controlled to switch on alternately by the controller, and the third switches, the fourth switches and the fifth switches of other selecting assemblies except the M^{th} selecting assembly are controlled to switch off by the controller.

15. The capacitance detecting circuit of any of claims 3-13, wherein when an M^{th} induction-unit is scanned under a fullscreen synchronous mode, the fifth switch of an M^{th} selecting assembly is controlled to switch off by the controller, the third switch and the fourth switch of the M^{th} selecting assembly are controlled to switch on alternately by the controller, the third switches of other selecting assemblies except the M^{th} selecting assembly are controlled to switch off by the controller, and the fourth switches and the fifth switches of other selecting assemblies except the M^{th} selecting assembly are controlled to switch on alternately by the controller.

16. The capacitance detecting circuit of any of claims 1-15, wherein a currently scanned induction unit is judged to be touched when the count value is smaller than a first count threshold and larger than a second count threshold.

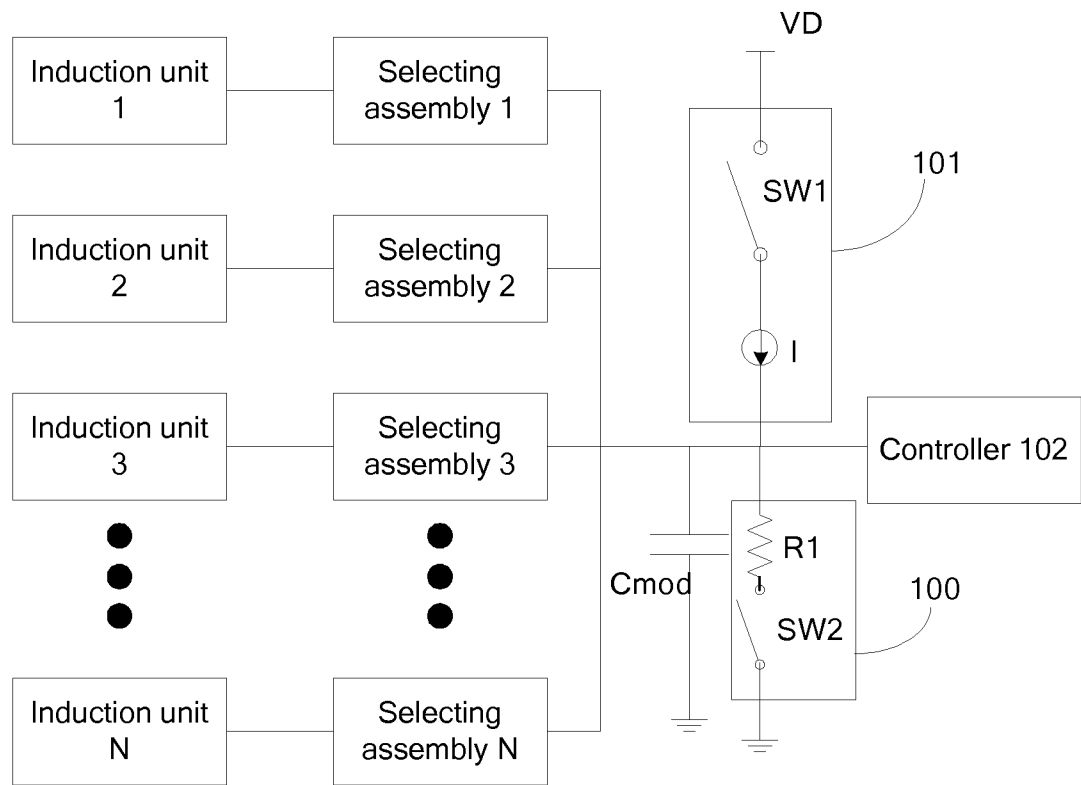


Fig. 1

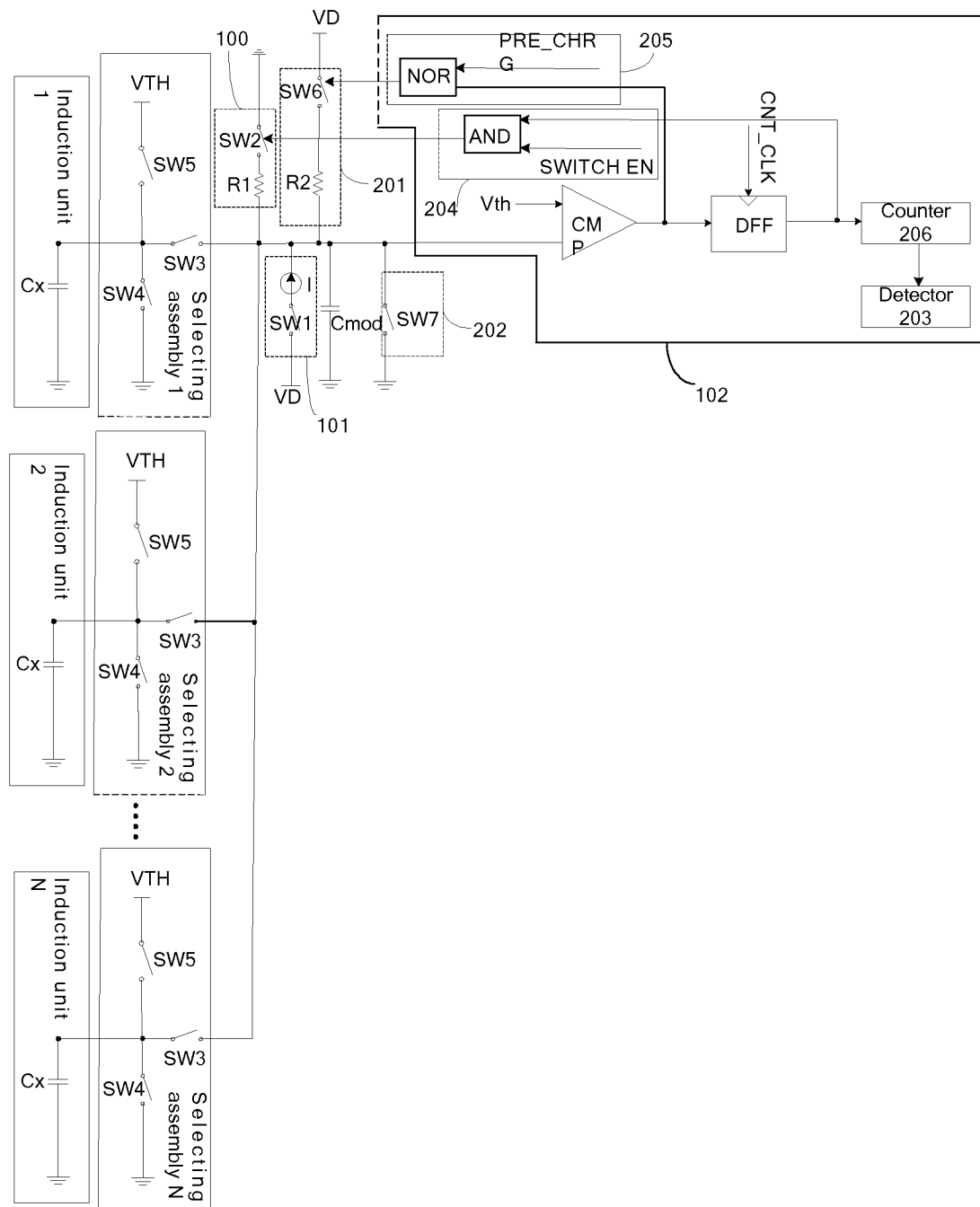


Fig. 2

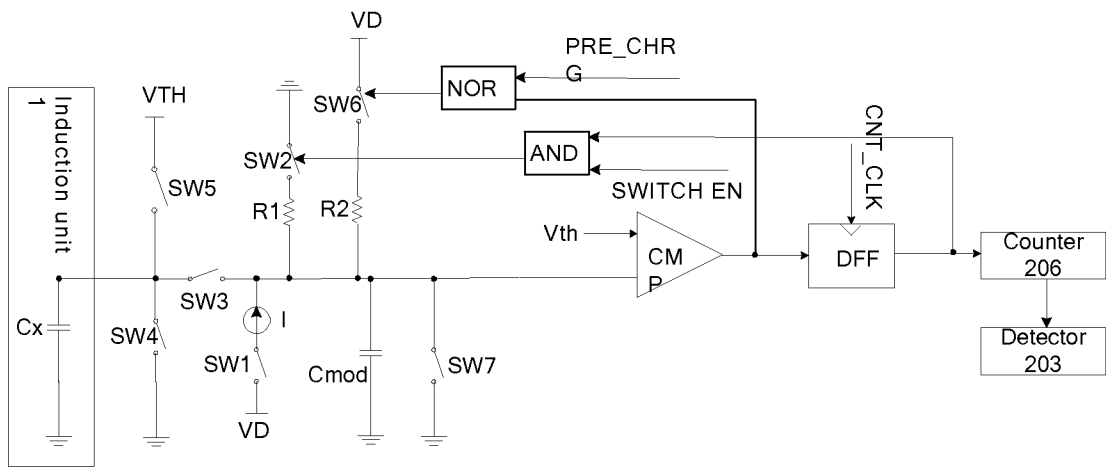


Fig. 3

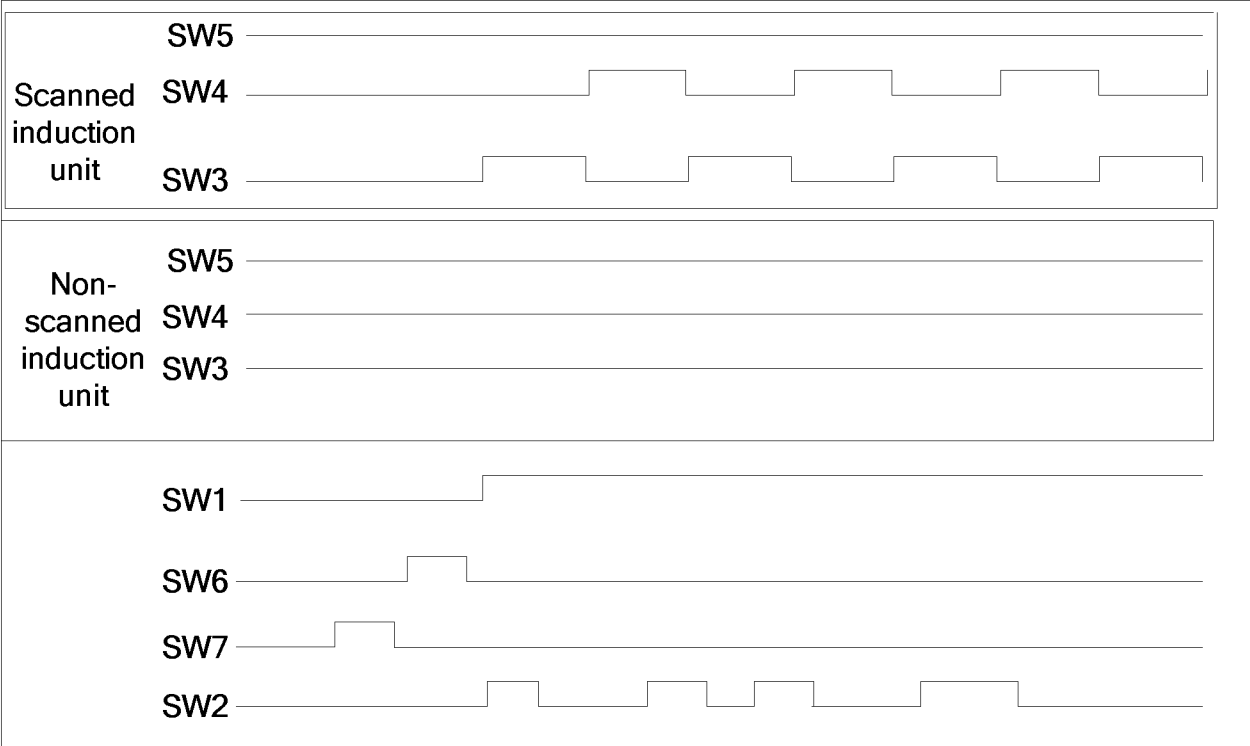


Fig. 4

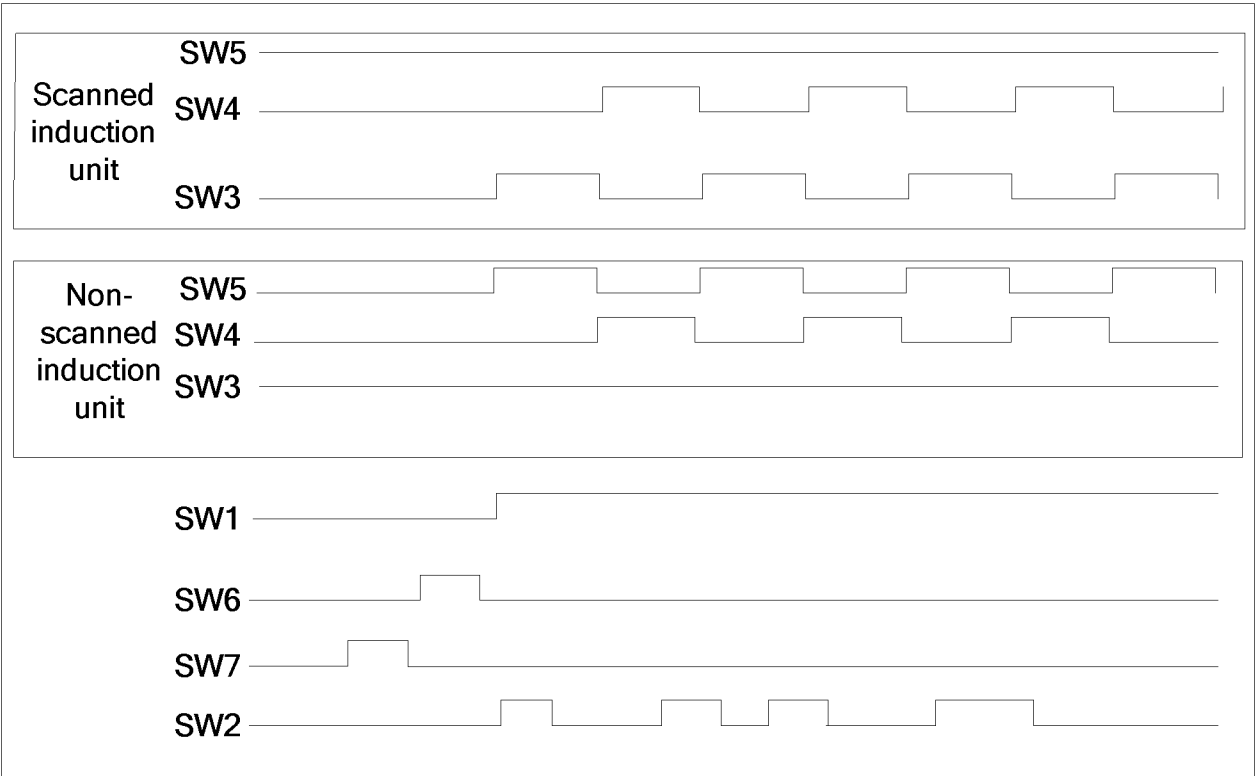


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/090888

A. CLASSIFICATION OF SUBJECT MATTER

G06F 3/044 (2006.01) i

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: G06F; G01R; H03K; G02F; G09G

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)

CNPAT, WPI, EPODOC, CNKI: capacit+, detect+, charg+, discharg+, count+, control+, touch+, check+, test+, mutual

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 101430436 A (EPSON IMAGING DEVICES CORP.) 13 May 2009 (13.05.2009) description, pages 9-12, and figures 6-8	1-16
Y	CN 101060321 A (BEIJING SIGMACHIP CO., LTD.) 24 October 2007 (24.10.2007) description, pages 5-7, and figure 1	1-16
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☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search 20 March 2014 (20.03.2014)	Date of mailing of the international search report 03 Apr. 2014 (03.04.2014)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer GUO, Haibo Telephone No. (86-10)61648258

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International application No.
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