

part of the antenna is placed around the transparent conductive material.

[0004] The prior art has the following disadvantages:~~During implementation of the present invention, the inventor finds that the prior art has at least the following problems:~~

5 [0005] A conventional mobile terminal or portable device has a relatively low requirement on an antenna gain, an antenna and a touch display screen can be arranged in different locations of the mobile terminal or portable device, and arrangement requirements of the touch display screen and the antenna can be completely met. However, in a millimeter-wave wireless communications system that
10 uses high-frequency communications technologies, the millimeter-wave wireless communications system has a significantly increased requirement on the antenna gain, and therefore an antenna size (or a physical aperture) increases. Moreover, due to a consideration on a visual effect, if a size of the mobile terminal or portable device is limited, a size of the touch display screen of the mobile terminal or portable device
15 becomes increasingly large, an area available for the antenna becomes increasingly small, and a touchscreen area of the mobile terminal or portable device cannot be efficiently utilized.

SUMMARY

[0006] In order to resolve the foregoing problems in the prior art, embodiments of
20 the present invention provide a sensing screen, a control circuit and control method thereof, and a sensing screen apparatus. The technical solutions are as follows:

[0007] According to a first aspect, an embodiment of the present invention provides a sensing screen, where the sensing screen includes a display screen, a first transparent medium layer, a transparent connection layer, and a transparent antenna
25 layer, where the first transparent medium layer is sandwiched between the connection layer and the antenna layer, and the connection layer is sandwiched between the first transparent medium layer and the display screen; and

the antenna layer includes multiple antenna units, and the multiple antenna units include at least one first antenna unit and multiple second antenna units, where
30 the first antenna unit is configured to transmit a sensing signal, and the second antenna units are configured to receive reflected signals of the sensing signal, where the reflected signals are generated by a touch object by reflecting the sensing signal, or the first antenna unit and the second antenna units are configured to simultaneously

[0046] FIG. 6a is a schematic diagram of a locating algorithm of a sensing screen according to Embodiment 6 of the present invention; and

[0047] FIG. 7 is a schematic structural diagram of a sensing screen apparatus according to Embodiment 7 of the present invention.

5 FIG.7a is another schematic structural diagram of a sensing screen apparatus according to Embodiment 7 of the present invention;

FIG.7b is another schematic structural diagram of a sensing screen apparatus according to Embodiment 7 of the present invention;

10 FIG.7c is another schematic structural diagram of a sensing screen apparatus according to Embodiment 7 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0048] To make the objectives, technical solutions, and advantages of the present invention clearer, the following further describes the embodiments of the present invention in detail with reference to the accompanying drawings.

Embodiment 1

15 [0049] This embodiment of the present invention provides a sensing screen. Referring to FIG. 1 and FIG. 1a, the sensing screen includes a display screen 1, a connection layer 2, a transparent antenna layer 3, and a first transparent medium layer 4. The first transparent medium layer 4 is sandwiched between the connection layer 2 and the antenna layer 3, and the connection layer 2 is sandwiched between the first transparent medium layer 4 and the display screen 1. The antenna layer 3 includes multiple antenna units 31, and the multiple antenna units 31 include at least one first antenna unit 311 and multiple second antenna units 312. An antenna of the first antenna unit 311 is configured to transmit a sensing signal, and antennas of the second antenna units 312 are configured to receive reflected signals of the sensing signal, where the reflected signals are generated by a touch object by reflecting the sensing signal. Alternatively, the first antenna unit 311 and the second antenna units 312 are all configured to simultaneously transmit or receive a communication signal. The multiple second antenna units 312 are interspersed with the first antenna unit 311.

20 [0050] When the first antenna unit 311 and the second antenna units 312 are configured to generate a communication signal, for example, when a mobile phone to which the sensing screen is applied is on a call, the first antenna unit 311 may be construed as the second antenna unit 312. When the antenna of the first antenna unit 311 is configured to transmit a sensing signal, and the antennas of the second antenna units 312 are configured to receive reflected signals of the sensing signal, the sensing screen may be used as a non-contact display screen of a terminal.

[0051] According to this embodiment of the present invention, an antenna layer made of a transparent material, a transparent connection layer, a first transparent medium layer, and a display screen are used to make a sensing screen, and the antenna layer is arranged right above the display screen, so that a touch area of the sensing screen is fully utilized while screen display is not affected, so as to substantially increase an antenna size and increase an antenna gain. In addition, a first antenna unit transmits a sensing signal, second antenna units receive reflected signals of the sensing signal, and a location corresponding to a touch object is determined according to the reflected signals, so as to implement a sensing function without adding extra costs, thereby reducing costs and achieving use convenience.

Embodiment 2

[0052] This embodiment of the present invention provides a sensing screen. Referring to FIG. 2, the sensing screen includes a display screen 1, a transparent connection layer 2, a transparent antenna layer 3, and a first transparent medium layer 4. The first transparent medium layer 4 is sandwiched between the connection layer 2 and the antenna layer 3, and the connection layer 2 is sandwiched between the first transparent medium layer 4 and the display screen 1. The antenna layer 3 includes multiple antenna units 31, and the multiple antenna units 31 include at least one first antenna unit 311 and multiple second antenna units 312. An antenna of the first antenna unit 311 is configured to transmit a sensing signal, and antennas of the second antenna units 312 are configured to receive reflected signals of the sensing signal, where the reflected signals are generated by a touch object by reflecting the sensing signal. Alternatively, the first antenna unit 311 and the second antenna units 312 are configured to simultaneously transmit or receive a communication signal. The multiple second antenna units 312 are interspersed with the first antenna unit 311.

[0053] The display screen 1 may use either an LED (Light Emitting Diode, ~~light emitting diode~~) display screen or an LCD (Liquid Crystal Display, ~~liquid crystal display~~).

[0054] The first transparent medium layer 4 is configured to transmit the sensing signal, the reflected signals, and the communication signal. The first transparent medium layer 4 may use transparent glass or air. When the first transparent medium layer 4 uses air, a medium structure is further needed for supporting.

[0055] In this embodiment, the connection layer 2 includes a shield layer 21 and a ground layer 22 (not shown in the figure). The shield layer 21 is configured to shield the antenna layer 3 and return the communication signal, the sensing signal, and the reflected signals. The ground layer 22 is configured to ground the antenna layer 3.

5 The ground layer 22 may be a protrusion disposed on the shield layer 21, and the protrusion may be soldered on a circuit board, so as to implement a grounding function. During implementation, the shield layer 21 and the ground layer 22 may be made of materials such as ITO (Indium Tin Oxide, ~~indium tin oxide~~).

[0056] In another implementation manner, the shield layer 21 and the ground
10 layer 22 may also be integrated into one layer.

[0057] During implementation, the antenna layer 3 includes multiple antenna feeders 32 that feed the antenna units 31. Referring to FIG. 2b and FIG. 2c, the antenna units 31 are arranged uniformly, and each antenna feeder 32 is connected to one antenna unit 31. Alternatively, each antenna feeder 32 is connected to multiple
15 antenna units 31, and different antenna feeders 32 are connected to different antenna units 31.

[0058] In this embodiment, referring to FIG. 2a, all the antenna units 31 form an antenna array, a radiation direction of an array formed by some antenna units, that is, antenna units 313, of the antenna array is parallel with the display screen 1, and a
20 radiation direction of an array formed by the other antenna units, that is, antenna units 314, of the antenna array is perpendicular to the display screen 1. During implementation, amplitude and a phase of a signal in each antenna unit may be adjusted to change a beam direction of the antenna array within a ~~certain~~ range, so as to form a radiation pattern (or an antenna directivity pattern) that is of the antenna
25 array and that covers the entire display screen. It can be easily understood that, the radiation direction of the array formed by the antenna units is affected by a type of the antenna units, a manner of connection between the antenna feeders and the antenna units, and a phase and amplitude of a signal generated in the antenna units.

[0059] The antenna units are made of one or more of ITO, FTO (Fluorine-doped
30 Tin Oxide, ~~fluorine doped tin oxide~~), ZnO:Al (Aluminum-doped Zinc Oxide, ~~aluminum doped zinc oxide~~), and ZnO:In (Indium-doped Zinc Oxide, ~~indium doped zinc oxide~~). During implementation, the antenna units may be low-profile antennas. The low-profile antennas may include one or more of a patch antenna, a slot antenna, a Vivaldi antenna, and a low-profile high-gain vertically polarized omnidirectional

communication signal.

[0076] The frequency conversion unit 404 is configured to perform frequency conversion on the sensing signal, the reflected signals, and the communication signal, so as to convert ~~frequencies of~~ the sensing signal, the reflected signals, and the communication signal between a radio frequency signal, an intermediate frequency signal, and a baseband signal. Referring to FIG. 4c, the frequency conversion unit 404 may include a local oscillator 4041, a mixer 4042, a filter 4043, and an amplifier 4044.

[0077] The power division and combination unit 405 is configured to perform power division on the sensing signal, perform power combination on the reflected signals, and perform power combination or power division on the communication signal.

[0078] The conversion unit 501 is configured to implement conversion between the sensing signal and a digital signal, between the reflected signals and digital signals, and between the communication signal and a digital signal. The conversion unit 501 includes at least an analog-to-digital conversion subunit and a digital-to-analog conversion subunit.

[0079] The digital signal processing unit 502 is configured to perform modulation and demodulation on the communication signal, the sensing signal, and the reflected signals, determine power of the reflected signals, and determine the location of the touch object according to the reflected signals and the power of the reflected signals. It can be easily understood that, the digital signal processing unit 502 includes at least a modulation subunit, a demodulation subunit, and a calculation subunit.

[0080] The control unit 503 is configured to control the adjustment unit 401 to perform phase or delay adjustment on a current signal, or control the adjustment unit 401 to perform amplitude adjustment on a current signal.

[0081] It should be noted that, the control circuit further includes a service processing unit 60 configured to perform conversion of a communications protocol. The service processing unit 60 is connected to the digital signal processing unit 502.

[0082] According to this embodiment of the present invention, an antenna layer made of a transparent material, a transparent connection layer, a first transparent medium layer, and a display screen are used to make a sensing screen, and the antenna layer is arranged right above the display screen, so that a touch area of the sensing screen is fully utilized while screen display is not affected, so as to substantially

next time.

[0112] It should be noted that, after the sensing screen is used for a ~~certain~~ period of time, for example, one month or three months, the stored coordinates of the touch object on the plane may further provide reference information for a next check. For example, a register or the like may be used to store effective coordinates of the touch object on the plane (that is, coordinates of the touch object on the plane that exceed no edge of the sensing screen) together, and when coordinates of a current touch object on a plane are calculated, that is, in step 608, the coordinates of the current touch object on the plane may be directly matched with those in the register, so as to improve sensing speed and reliability.

[0113] It can be easily understood that, the coordinates of the touch object on the plane when the coordinates of the touch object on the plane exceed an edge of the sensing screen are stored, so that determining can be performed more rapidly when a first antenna unit is selected next time or at a next check, and therefore the sensing speed and reliability can also be improved. During implementation, when the coordinates of the touch object on the plane exceed an edge of the sensing screen, a quantity of sensing errors may further be recorded, and when a value of a counter reaches a set value, an error warning is sent.

[0114] In this embodiment, the method may further include:

according to the coordinates of the touch object on the plane and the distance from the touch object to the sensing screen, controlling a beam angle generated by the antenna units in a communication timeslot, where the touch object is located outside the generated beam angle.

[0115] The distance from the touch object to the sensing screen may be calculated in the following manner:

[0116] If the four antenna units with highest power are used in step 604, the distance from the touch object to the sensing screen may be directly obtained according to the equations (1) to (3) in step 606.

[0117] If the three antenna units with highest power are used in step 604, the distance from the touch object to the sensing screen may be obtained according to time differences between transmitting of the sensing signal and receiving of the reflected signals, propagation speed of the sensing signal and the reflected signals, and distances between the first antenna unit that transmits the sensing signal and the second antenna units that receive the reflected signals.

close to the sensing screen. The warning information may be displayed on a display screen, so as to prompt the user to avoid the problem, thereby improving radiation protection of the antenna units in the sensing screen.

[0124] According to this embodiment of the present invention, an antenna layer made of a transparent material, a transparent connection layer, a first transparent medium layer, and a display screen are used to make a sensing screen, and the antenna layer is arranged right above the display screen, so that a touch area of the sensing screen is fully utilized while screen display is not affected, so as to substantially increase an antenna size and increase an antenna gain. In addition, a first antenna unit transmits a sensing signal, second antenna units receive reflected signals of the sensing signal, and a location corresponding to a touch object is determined according to the reflected signals, so as to implement a sensing function without adding extra costs, thereby reducing costs and achieving use convenience.

Embodiment 7

[0125] This embodiment of the present invention provides a sensing screen apparatus. Referring to FIG. 7, the apparatus includes a sensing screen 71 corresponding to Embodiment 1 and Embodiment 2 and a control apparatus 72. The control apparatus 72 includes a housing 721 and a control circuit 722 that is corresponding to Embodiment 3 and Embodiment 4. The control circuit 722 is disposed in the housing 721. The control circuit 722 is connected to the sensing screen 71 by using the housing 721.

[0126] During implementation, the sensing screen 71 may be connected to the control circuit 722 by using a jumper, or a connector, or a slot 721a disposed on the housing 721. In a manner in which the sensing screen 71 is connected to the control circuit 722 by using the slot 721a disposed on the housing 721, referring to FIG. 7a, a side surface of the sensing screen 71 is provided with an extended protrusion 711, where the extended protrusion 711 is a conductor, and the conductor may be mounted in the slot 721a. In a manner in which the sensing screen 71 is connected to the control circuit 722 by using a jumper 73 or the connector (not shown in the figure), referring to FIG. 7b and FIG. 7c, a connecting line 731 is further connected on the sensing screen 71 and the control circuit 722. Preferably, the sensing screen 71 is connected to the control circuit 722 by using the slot 721a disposed on the housing

| the ~~spirit and~~ principle of the present invention shall fall within the protection scope
of the present invention.

CLAIMS

What is claimed is:

1. A sensing screen, wherein the sensing screen comprises a display screen, a first transparent medium layer, a transparent connection layer, and a transparent antenna layer, wherein the first transparent medium layer is sandwiched between the connection layer and the antenna layer, and the connection layer is sandwiched between the first transparent medium layer and the display screen; and

the antenna layer comprises multiple antenna units, and the multiple antenna units comprise at least one first antenna unit and multiple second antenna units, wherein the first antenna unit is configured to transmit a sensing signal, and the second antenna units are configured to receive reflected signals of the sensing signal, wherein the reflected signals are generated by a touch object by reflecting the sensing signal, or the first antenna unit and the second antenna units are configured to simultaneously transmit or receive a communication signal, and the multiple second antenna units are interspersed with the first antenna unit.

2. The sensing screen according to claim 1, wherein the antenna layer comprises multiple antenna feeders configured to feed the antenna units, each antenna feeder is connected to one antenna unit, or each antenna feeder is connected to multiple antenna units, and different antenna feeders are connected to different antenna units.

3. The sensing screen according to claim 1 or 2, wherein all the antenna units form an antenna array, a radiation direction of an array formed by some antenna units in the antenna array is parallel with the display screen, and a radiation direction of an array formed by the other antenna units in the antenna array is perpendicular to the display screen.

4. The sensing screen according to any one of claims 1~3, wherein the antenna units are made of one or more of indium tin oxide, fluorine-doped tin oxide, aluminum-doped zinc oxide, and indium-doped zinc oxide.

5. The sensing screen according to any one of claims 1~4 ~~claim 3~~, wherein the antenna units are low-profile antennas, and the low-profile antennas comprise one or more of a patch antenna, a slot antenna, and a Vivaldi antenna.

6. The sensing screen according to any one of claims 1~5, wherein the connection layer comprises a shield layer and a ground layer, wherein the shield layer is configured to

shield the antenna layer and return the communication signal, the sensing signal, and the reflected signals, and the ground layer is configured to ground the antenna layer.

7. The sensing screen according to any one of claims 1~6, wherein the sensing screen further comprises a second transparent medium layer disposed between the display screen and the connection layer.

8. The sensing screen according to any one of claims 1 to 7, wherein the sensing screen further comprises a transparent protective layer that overlies the antenna layer, and the transparent protective layer and the first transparent medium layer are located on two sides of the antenna layer.

9. A control circuit of a sensing screen, configured to control the sensing screen according to any one of claims 1 to 8, wherein the control circuit comprises an adjustment module and a control module, wherein: the adjustment module is controlled by the control module to adjust a sensing signal, reflected signals, and a communication signal, the control module is further configured to determine a location of a touch object according to the adjusted sensing signal and reflected signals, and the adjustment module is electrically connected to the sensing screen and the control module ~~separately~~.

10. The control circuit according to claim 9, wherein the adjustment module comprises:

a radio frequency front-end channel, configured to receive the sensing signal, the reflected signals, and the communication signal, and perform standing-wave detection, signal amplification, and filtering on the sensing signal, the reflected signals, and the communication signal;

an adjustment unit, configured to adjust amplitude, a phase, or a delay of the sensing signal, the reflected signals, and the communication signal;

a frequency conversion unit, configured to perform frequency conversion on the sensing signal, the reflected signals, and the communication signal; and

a power division and combination unit, configured to perform power division on the sensing signal, perform power combination on the reflected signals, and perform power combination or power division on the communication signal.

11. The control circuit according to claim 10, wherein the radio frequency front-end channel, the adjustment unit, the power division and combination unit, and the frequency conversion unit are sequentially connected between the sensing screen and the control module; or

the radio frequency front-end channel, the adjustment unit, the frequency conversion unit, and the power division and combination unit are sequentially connected between the sensing screen and the control module; or

the radio frequency front-end channel, the frequency conversion unit, the adjustment unit, and the power division and combination unit are sequentially connected between the sensing screen and the control module.

12. A sensing screen apparatus, wherein the sensing screen apparatus comprises the sensing screen according to any one of claims 1 to 8 and a control apparatus, wherein the control apparatus comprises a housing and the control circuit according to any one of claims 9 to 11, the control circuit is disposed in the housing, and the control circuit is connected to the sensing screen by using the housing.

13. The sensing screen apparatus according to claim 12, wherein the sensing screen is connected to the control circuit by using a jumper, or a connector, or a slot disposed on the housing.

14. A control method of a sensing screen, ~~used to control the sensing screen according to any one of claims 1 to 8~~, wherein the method comprises:

in a sensing timeslot, controlling a first antenna unit in the sensing screen to transmit a sensing signal, and controlling second antenna units to receive reflected signals of the sensing signal, wherein the reflected signals are generated by a touch object by reflecting the sensing signal; and

when the reflected signals of the sensing signal are received, determining coordinates of the touch object on a plane on which the sensing screen is located, according to power of the received reflected signals and coordinates, of the second antenna units that receive the reflected signals, on the plane.

15. The method according to claim 14, wherein the method further comprises:

in a communication timeslot, controlling the antenna units to simultaneously transmit or receive a communication signal.

16. The method according to claim 14 ~~or~~ 15, wherein one or more sensing timeslots are inserted in one communication timeslot in a spaced manner or are inserted between two adjacent communication timeslots in a spaced manner.

17. The method according to any one of claims 14~16, wherein the controlling a first antenna unit in the sensing screen to transmit a sensing signal comprises:

randomly selecting one antenna unit from the multiple antenna units, or selecting one antenna unit with highest frequency of use from the multiple antenna units; and

controlling the selected one antenna unit to transmit the sensing signal.

18. The method according to any one of claims 14~17, wherein the determining coordinates of the touch object on a plane on which the sensing screen is located, according to power of the received reflected signals and coordinates, of the second antenna units that receive the reflected signals, on the plane comprises:

selecting four reflected signals with highest power from the received reflected signals;

determining coordinates of four second antenna units that receive the four selected reflected signals; and

determining the coordinates of the touch object on the plane according to the four selected reflected signals and the coordinates of the four second antenna units.

19. The method according to claim 18, wherein the determining the coordinates of the touch object on the plane according to the four selected reflected signals and the coordinates of the four second antenna units comprises:

detecting whether power of the four reflected signals reaches a set threshold; and
reselecting a first antenna unit when power of one reflected signal among the four reflected signals does not reach the set threshold.

20. The method according to any one of claims 14~19, wherein the method further comprises:

checking whether the coordinates of the touch object on the plane exceed an edge of the sensing screen, to obtain a check result; and

when the check result is that the coordinates of the touch object on the plane exceed no edge of the sensing screen, generating an operation control instruction according to the coordinates of the touch object on the plane.

21. The method according to claim 20, wherein the method further comprises:

storing the coordinates of the touch object on the plane and the check result of the coordinates of the touch object on the plane.

22. The method according to any one of claims 14~21, wherein the method further comprises:

according to the coordinates of the touch object on the plane and a distance from the touch object to the sensing screen, controlling a beam angle generated by the antenna units in the communication timeslot, wherein the touch object is located outside the generated beam angle.

23. The method according to any one of claims 14~22, wherein the method further comprises:

separately detecting whether strength of a reflected signal received by each antenna unit reaches a set threshold; and