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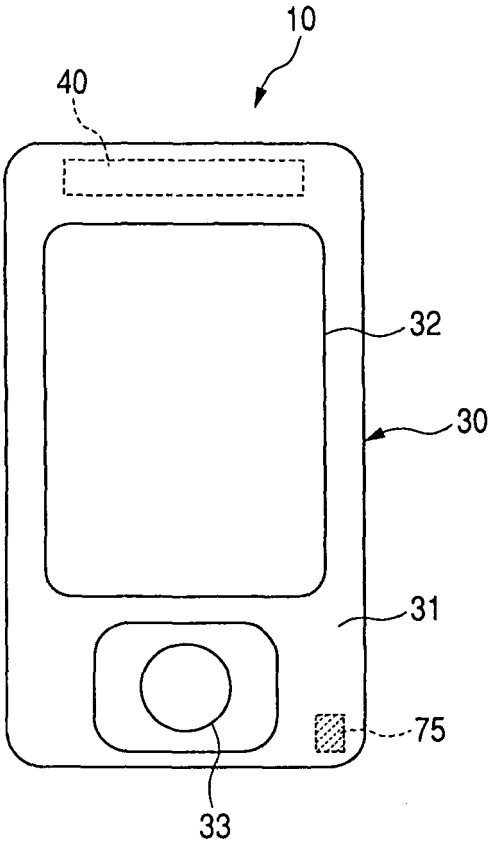
(54) Mobile device

(57) Provided is a mobile device (10) having first and second housings (20) and (30) of which positional relationship is variable, including: in the first and second housings (20) and (30), an antenna element (40a) for receiving television signals; a matching circuit (40b) including a variable capacitance element to perform matching with the antenna element (40a); a television signal receiver circuit (60) connected to the matching circuit (40b); a control circuit (63) controlling a tuning voltage to be supplied to the variable capacitance element; and a sensing unit (71) and (75) detecting the positional relationship between the first and second housings (20) and (30), wherein the control circuit (63) controls the tuning voltage according to the positional relationship between the first and second housings (20) and (30) represented by the detection result of the sensing unit (71) and (75).

FIG. 1A



EP 2 068 395 A1

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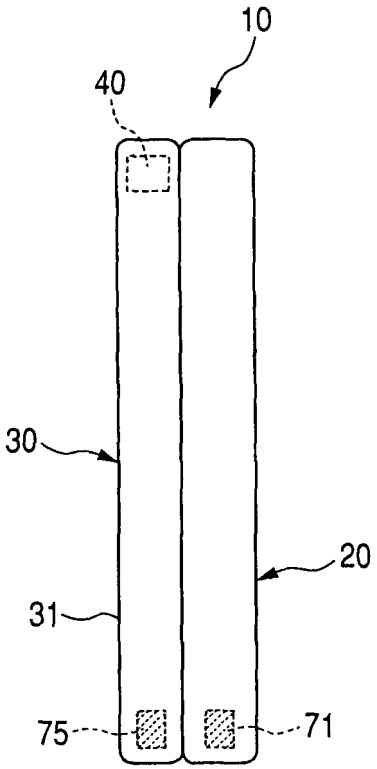
FIG. 1B



Description

Cross Reference to Related Applications

[0001] The present invention contains subject matter related to Japanese Patent Application No. 2007-314546 filed in the Japanese Patent Office on December 5, 2007, the entire contents of which being incorporated herein by reference.

BACKGROUND

1. Technical Field

[0002] The present invention relates to a mobile device, and more particularly, to a mobile device configured to receive television broadcasting such as terrestrial digital broadcasting and the like.

2. Related Art

[0003] There are mobile phones that have a function of receiving television broadcasting. Particularly, for the function, a mobile phone that has an antenna in a housing and performs tuning control using a variable tuning circuit has been developed (see JP-A-2006-41840).

[0004] There is a mobile phone that has first and second housings, a display screen provided to the one of the housings, and operating keys provided to the other one thereof (see JP-A-2006 - 332795). The first and second housings of the mobile phone are connected by means such as a hinge to rotate relative to each other, so that a positional relationship therebetween is variable.

SUMMARY

[0005] However, circuit boards having conductive foils in ground patterns and components with metal such as circuit elements and connectors shielded by metal are included in the first and second housings. In addition, when an angle between the first and second housings is changed by the rotation therebetween, a reception condition of the antenna is also changed. Therefore, as described above, the positional relationship between the first and second housings of the mobile phone can be changed and the reception condition of the antenna can also be changed due to the changed positional relationship, so that there is a problem in that good reception is difficult.

[0006] It is desirable to provide a mobile device capable of performing good reception even when a positional relationship between multiple housings of the mobile device is changed.

[0007] According to an aspect of the invention, the mobile device having first and second housings of which positional relationship is variable, includes: in the first and second housings, an antenna element for receiving television signals; a matching circuit including a variable capacitance element to perform matching with the antenna element; a television signal receiver circuit connected to the matching circuit; a control circuit controlling a tuning voltage to be supplied to the variable capacitance element; and a sensing unit detecting the positional relationship between the first and second housings, wherein the control circuit controls the tuning voltage according to the positional relationship between the first and second housings represented by the detection result of the sensing unit.

[0008] With such a configuration, the tuning voltage according to the positional relationship between the first and second housings which influences the reception condition is supplied to an antenna module, so that accurate reception is possible even when the positional relationship between the first and second housings is changed.

[0009] In the mobile device according to the aspect of the invention, at least one of the first and second housings may include a display for displaying images demodulated from the received television signal.

[0010] In this case, in the mobile device having the first and second housings of which the positional relationship is variable and at least one is provided with the display to display the received television broadcasting, a user holds the other side housing (the first housing) and moves the housing having the display in order to use the mobile device. Specifically, in the mobile device of which the housing has the display, various relationships between the first and second housings exist as the positional relationship therebetween. In this situation, a tuning voltage according to the corresponding positional relationship is supplied to the antenna module, so that accurate reception according to the positional relationship between the first and second housings is always possible.

[0011] In the mobile device according to the embodiment of the invention, the control circuit may include a storage unit for storing a correspondence table representing correspondence between the positional relationship of the first and second housings and the tuning voltage. With such a configuration, the tuning voltage can be selected according to the positional relationship between the first and second housings by referring to the correspondence table.

[0012] In the mobile device according to the embodiment of the invention, the sensing unit may include a magnet provided to at least one of the first and second housings and a magnetism sensor provided to the other one of the first and second housings.

[0013] With such a configuration, when the first and second housings are in a predetermined state, a positional relationship between the magnet provided to the one housing and the sensor provided to the other housing is allowed to be a predetermined relationship, so that the positional relationship between the housings can be detected by the output from the sensor.

[0014] According to the embodiment of the present invention, good reception is possible even when the positional relationship between multiple housings of the mo-

bile device is changed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1A is a front view illustrating the outer appearance of a mobile phone in a closed state according to a first embodiment of the invention, and Fig. 1B is a side view illustrating the outer appearance of the mobile phone in the closed state.

Fig. 2A is a front view illustrating the outer appearance of the mobile phone in a use state according to the first embodiment of the invention, and Fig. 2B is a side view illustrating the outer appearance of the mobile phone in the use state.

Fig. 3 is a perspective view illustrating a circuit board included in a second housing and an antenna module provided to a surface of the circuit board.

Fig. 4 is a perspective view illustrating the outer appearance of the antenna module.

Fig. 5 is a connection diagram illustrating a configuration of a matching circuit of the antenna module.

Fig. 6 is a block diagram illustrating a configuration of the antenna module and a receiver circuit.

Fig. 7 is a view illustrating a relationship between tuning voltages used in the use state and tuning voltages used in the closed state corresponding to each reception channel.

Fig. 8 is a view for explaining tuning voltage supply means in the receiver circuit.

Fig. 9 is a view illustrating changes in voltage standing wave ratio (VSWR) characteristics due to changes in the tuning voltages.

Fig. 10A is a front view illustrating the outer appearance of a mobile phone in a closed state according to a second embodiment of the invention, and Fig. 10B is a side view illustrating the outer appearance of the mobile phone in the closed state.

Fig. 11A is a front view illustrating the outer appearance of the mobile phone in a use state according to the second embodiment of the invention, and Fig. 10B is a side view illustrating the outer appearance of the mobile phone in the use state.

Fig. 12A is a front view illustrating the outer appearance of the mobile phone in a folded-back state according to the second embodiment of the invention, and Fig. 10B is a side view illustrating the outer appearance of the mobile phone in the folded-back state.

Fig. 13 is a block diagram illustrating a configuration of an antenna module and a receiver circuit according to the second embodiment.

Fig. 14 is a view illustrating a relationship between tuning voltages used in the use state, tuning voltage used in the closed state, and tuning voltage used in the folded-back state corresponding to each reception channel.

Fig. 15 is a front view illustrating the outer appearance of a mobile phone in a horizontally long display state according to another embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0016] Hereinafter, a mobile device according to embodiments of the invention will be described in detail with reference to the accompanying drawings.

First Embodiment

[0017] Figs. 1 and 2 are views illustrating the appearance of a mobile phone 10 that is an example of the mobile device according to the embodiment of the invention. The mobile phone 10 includes a first housing 20 having an operating surface 21 provided with operating keys 22 for inputting phone numbers and the like, a microphone (not shown), and the like, and a second housing 30 having an operating surface 31 provided with a liquid crystal display unit 32, operation keys 33, a speaker (not shown), and the like.

[0018] The second housing 30 is slidably supported with respect to the first housing 20 by a slide member (not shown). Fig. 1 illustrates a closed state in which the first and second housings 20 and 30 overlap with each other. In this state, since the second housing 30 overlaps with the operating surface 21 of the first housing 20, the outer size of the mobile phone 10 constructed with the first and second housings 20 and 30 is reduced so as to enable the mobile phone 10 to be easily stored. On the other hand, Fig. 2 illustrates a use state in which the first and second housings 20 and 30 in the closed state in Fig. 1 slide past each other and the operating keys 22 provided to the operating surface 21 of the first housing 20 are exposed. As illustrated in Fig. 2, the operating surfaces 21 and 31 of the first and second housings 20 and 30, respectively, face the same direction in the use state.

[0019] When a user does not use the mobile phone 10, the user may allow the first and second housings 20 and 30 that can slide past each other to be in the closed state for portability, and when the user uses the mobile phone 10, the user may allow the first and second housings 20 and 30 to be in the use state so that the liquid crystal display unit 32 and the operating keys 22 are exposed in the same direction and can be simultaneously used.

[0020] The mobile phone 10 includes an antenna module 40 in the second housing 30 to receive television broadcasting (for example, terrestrial digital broadcasting) through the antenna module 40. The antenna module 40 is used for receiving television broadcasting, and an antenna module (not shown) for phone calls is additionally provided. For example, the antenna module for phone calls is included in the first housing 20 and provided in the vicinity of a lower portion in the figure. As described above, the antenna module 40 for receiving

television broadcasting and the antenna module for phone calls are separated as much as possible from each other to prevent interference therebetween.

[0021] Fig. 3 is a perspective view illustrating a circuit board 50 included in the second housing 30 and the antenna module 40 provided to a surface of the circuit board 50. As illustrated in Fig. 3, the circuit board 50 is a board having a shape to be included in the second housing 30 (see Figs. 1 and 2) and a base material 50a of which at least one surface is formed in a ground pattern 50b. A cut-out portion is formed at a part of the ground pattern 50b, and the antenna module 40 is directly attached to the base material through the cut-out portion.

[0022] As illustrated in Fig. 4, the antenna module 40 includes an antenna element 40a constructed with a base body 41 having a rectangular parallelepiped shape, a belt-like radiation conductor 42 wound on the base body 41 in a helical pattern, and a matching circuit 40b constructed with an LC series resonant circuit 43 including, for example, a varactor diode, a coil, and the like and formed at the surface of the base body 41. The matching circuit 40b can change a resonance frequency by changing capacitance of the varactor diode and equivalently changing reactance L, thereby changing a reception frequency band. The matching circuit 40b is connected to the ground pattern 50b with a ground line 45 and also connected to a tuner (not shown) with a power supply line 46. According to the embodiment, the base body 41 is composed of a resin material such as liquid crystal polymer but it is not limited thereto and may be composed of, for example, a dielectric material, a magnetic material, or a combination thereof. In addition, the antenna may have a film shape. Additionally, instead of the radiation conductor 42 wound in the helical pattern, a plurality of conductors having a ring shape may be worn, or a monopole-type conductor may be provided.

[0023] Fig. 5 is a connection diagram illustrating a circuit configuration of the matching circuit 40b. For the antenna element 40a, the matching circuit 40b includes a resistor R11, a pair of varactor diodes D11 and D12, coils L11 and L12, a condenser C11, and a resistor R13. The matching circuit 40b changes a voltage to be supplied to the varactor diodes D11 and D12 by changing a tuning voltage V_{tune} described later, thereby chanting the reception frequency band. Accordingly, a desired channel can be selected. At the same time, the tuning voltage can be adjusted (described later) according to a state (the closed state or the use state) of the first and second housings 20 and 30 of the mobile phone 10, and optimal tuning characteristics according to the state of the housings can be obtained.

[0024] Fig. 6 is a connection diagram illustrating a configuration of the antenna module 40 described above with reference to Fig. 4 and a receiver circuit 60 connected to the antenna module 40. As illustrated in Fig. 6, the matching circuit 40b of the antenna module 40 is connected to the receiver circuit 60 with the power supply line 46.

[0025] The receiver circuit 60 includes a mobile tuner 65 having a tuner 61 and a demodulation integrated circuit (IC) 62, and a control circuit 63. The tuner 61 performs frequency conversion on a radio frequency (RF) signal received from the antenna module 40 into a signal having a low frequency to perform digital demodulation. The demodulation IC 62 demodulates the reception signal output from the tuner 61 and outputs the demodulated signal to the control circuit 63. The control circuit 63 decodes an image signal by performing, for example, moving picture experts group (MPEG) decoding on the signal demodulated by the demodulation IC 62 and outputs the decoded image signal to the liquid crystal display unit 32. Accordingly, the images of television broadcasting received through the antenna module 40 are displayed on the liquid crystal display unit 32. In addition, the control circuit 63 performs processing such as changing a channel of the received television broadcasting according to operation results input through the operating keys 22 or 33.

[0026] The demodulation IC 62 is configured to transmit the tuning voltage V_{tune} for allowing a frequency band of a channel selected by the user to be the reception frequency to the matching circuit 40b of the antenna module 40 so as to tune the frequency band received through the antenna module 40 to the frequency band of the desired channel. The demodulation IC 62 is also configured to obtain optimal tuning characteristics according to the state of the housings by adjusting the tuning voltage V_{tune} according to the state (the closed state or the use state) of the first and second housings 20 and 30 of the mobile phone 10.

[0027] Specifically, a magnetic induction type sensor 71 for detecting magnetism is provided to the first housing 20 of the mobile phone 10. More specifically, as illustrated in Figs. 1A and 2A, the sensor 71 is fixed to a lower right corner of the first housing 20 in the figure, and a magnet 75 is fixed to a lower right corner of the second housing 30 in the figure. Accordingly, when the first and second housings 20 and 30 are in the closed state as illustrated in Fig. 1, the magnet 75 is close to the sensor 71. On the contrary, when the first and second magnets 20 and 30 are in the use state as illustrated in Fig. 2, the magnet 75 and the sensor 71 are separated from each other. Since the sensor 71 acquires different outputs according to distances from the magnet 75, a detecting signal output in the closed state illustrated in Fig. 1 and a detecting signal output in the use state illustrated in Fig. 2 have different levels from each other.

[0028] Therefore, the control circuit 63 of the receiver circuit 60 (see Fig. 6) provided to the first housing 20 can determine whether the first and second housings 20 and 30 are in the closed state or the use state, on the basis of the signal level of the detecting signal output from the sensor 71. The control circuit 63 transmits an indicating signal for indicating a tuning voltage value according to the closed state or the use state on the basis of the signal level of the detecting signal output from the sensor 71 to

the demodulation IC 62. The demodulation IC 62 supplies a tuning voltage V_{tune} according to the indicating signal obtained from the control circuit 63 to the matching circuit 40b of the antenna module 40.

[0029] Specifically, as illustrated in Fig. 7, the control circuit 63 sets a tuning voltage V_{tune1} used in the closed state and a tuning voltage V_{tune2} used in the use state for each channel of the television broadcasting in a correspondence table, selects the tuning voltage as the tuning voltage V_{tune1} used in the closed state or the tuning voltage V_{tune2} used in the use state, according to the signal level (the signal level corresponding to the closed state or the signal level corresponding to the use state) of the detecting signal received from the sensor 71, and transmits an indicating signal for indicating the selected tuning voltage to the demodulation IC 62. According to the embodiment, the correspondence table is stored in a storage unit 63a included in the control circuit 63 but not limited thereto. For example, the correspondence table may be stored in a storage unit provided outside the control circuit 63.

[0030] More specifically, when the user selects, for example, a channel CH1 by manipulating the operating keys 22, the control circuit 63 determines whether the housings are in the closed state or the use state on the basis of the detecting signal received from the sensor 71. When the housings are in the closed state, the control circuit 63 selects the tuning voltage V_{tune1} (=1.4 V) used in the closed state corresponding to the channel CH1 and transmits the indicating signal for indicating this voltage to the demodulation IC 62. On the contrary, when the housings are in the use state, the control circuit 63 selects the tuning voltage V_{tune2} (=1.0 V) used in the use state corresponding to the channel CH1 and transmits the indicating signal for indicating this voltage to the demodulation IC 62.

[0031] The demodulation IC 62 transmits the tuning voltage V_{tune} indicated by the indicating signal received from the control circuit 63 to the matching circuit 40b of the antenna module 40. Specifically, as illustrated in Fig. 8, the demodulation IC 62 of the receiver circuit 60 transmits a pulse signal S_{PWM} having a pulse width according to the voltage indicated by the indicating signal to a tuning voltage generation circuit 66, on the basis of the indicating signal transmitted from the control circuit 63. The tuning voltage generation circuit 66 generates the tuning voltage V_{tune} in a direct current voltage level according to the pulse width of the pulse signal S_{PWM} by using a source voltage V_{CC} and supplies the generated tuning voltage V_{tune} to the matching circuit 40b through a resistor R14. In addition, a condenser C12 for blocking the direct current voltage is provided to a transmission line connecting the matching circuit 40b to the mobile tuner 65.

[0032] Accordingly, the optimal tuning voltage V_{tune} according to the state (the closed state or the use state) of the housings of the mobile phone 10 is supplied to the antenna module 40. As described above, as illustrated in Fig. 9, since voltage standing wave ratio (VSWR) characteristics of the antenna module 40 are changed by changing the tuning voltage V_{tune}, the reception frequency can be adjusted to the frequency of the channel to be received.

[0033] Otherwise, as represented by a dash line in Fig. 8, a direct current voltage S_{DAC} obtained by performing digital-to-analog conversion on the indicating signal transmitted from the control circuit 63 may be supplied to the antenna module 40 as the tuning voltage V_{tune}.

[0034] The operation of the mobile phone 10 having the aforementioned construction will be described. Since the liquid crystal display unit 32 of the mobile phone 10 is exposed in both of the closed state illustrated in Fig. 1 and the use state illustrated in Fig. 2, the received television broadcasting can be displayed on the liquid crystal display unit 32 in both states and provided to the user.

[0035] A positional relationship between the first and second housings 20 and 30 in the closed state and a positional relationship between the first and second housings 20 and 30 in the use state are different from each other. The reception condition of the antenna module 40 of the mobile phone 10 is changed according to the positional relationship between the first and second housings 20 and 30 including the ground pattern and various types of circuit components, so that the tuning voltage to be applied needs to be changed according to the positional relationships therebetween. In the receiver circuit 60 of the mobile phone 10, the optimal tuning voltages to be adjusted to the tuning characteristics in each state of the housings are stored in the form of the correspondence table in the storage unit 63a of the control circuit 63.

[0036] In the closed state illustrated in Fig. 1, the user can select a desired channel by manipulating the operating keys 33 of the second housing 30 which are operable in the closed state, and in the use state illustrated in Fig. 2, the user can select a desired channel by manipulating the operating keys 22 of the first housing 20 which are operable in the use state.

[0037] When a channel is selected by manipulating the operating keys 22 or 33, the control circuit 63 of the mobile phone 10 determines the state (the closed state in Fig. 1 or the use state in Fig. 2) of the housings on the basis of the detecting signal of the sensor 71. Thereafter, the control circuit 63 selects the tuning voltage corresponding to the state of the housings and the channel indicated by manipulating the operating keys 22 and 33 from the correspondence table illustrated in Fig. 7.

[0038] Accordingly, the selected tuning voltage is supplied to the antenna module 40, and broadcast waves of the indicated channel can be received with the optimal tuning characteristics according to the state of the housings.

[0039] In addition, when the state of the housings is changed while the television broadcasting of the channel selected by manipulating the operating keys 22 or 33 is received, the control circuit 63 detects the change in the

state on the basis of the detecting signal output from the sensor 71, selects a tuning voltage according to the changed state from the correspondence table illustrated in Fig. 7, changes the current tuning voltage to the selected tuning voltage, and supplied the selected tuning voltage to the antenna module 40.

[0040] For example, when television broadcasting of a channel 1 is received in the closed state (see Fig. 1), the tuning voltage supplied to the antenna module 40 is 1.4 V as illustrated in Fig. 7. When the closed state of the housings is changed to the use state (see Fig. 2) while the television broadcasting is received, the signal level of the detecting signal of the sensor 71 is changed, and the control circuit 63 changes the tuning voltage currently supplied to the antenna module 40 to the tuning voltage of 1.0 V according to the changed state. Accordingly, even when the state of the housings is changed while the television broadcasting is received, the optimal tuning characteristics can be obtained.

Second Embodiment

[0041] Figs. 10 to 12 are views illustrating the appearance of a mobile phone 110 according to a second embodiment. As compared with the mobile phone 10 according to the first embodiment described with reference to Fig. 1, a positional relationship between first and second housings 120 and 130 of the mobile phone 110 is different from that of the mobile phone 10. Therefore, like reference numerals in Figs. 1 and 10 to 12 denote like elements, and a detailed description thereof will be omitted.

[0042] Referring to Figs. 10 to 12, the mobile phone 110 includes the first and second housings 120 and 130 which are connected by a hinge 111 to rotate relative to each other in a direction represented by an arrow a. In addition, the first and second housings 120 and 130 connected by the hinge 111 can also rotate relative to each other in a direction represented by an arrow b.

[0043] The first housing 120 has operating keys 122 and 123 on an operating surface 121 to input phone numbers, select a channel for receiving television broadcasting, and the like. The second housing 130 has a liquid crystal display unit 132 on a display surface 131 to display an operating state of the mobile phone 110 and images of the selected channel when the television broadcasting is received.

[0044] Fig. 10 illustrates a closed state in which the first and second housings 120 and 130 overlap with each other. Fig. 11 illustrates a use state in which the operating surface 121 of the first housing 120 and the display surface 131 of the second housing 130 are exposed in the same direction. Fig. 12 illustrates a folded-back state in which the operating surface 121 of the first housing 120 and the other surface of the second housing 130 (the reverse side of the operating surface 131) face each other.

[0045] In the closed state illustrated in Fig. 10, the operating surface 121 of the first housing 120 and the display surface 131 of the second housing 131 face each other. As a result, in this state, the other surface of the second housing 130 (the reverse side of the display surface 131) is exposed.

[0046] On the other hand, in the use state illustrated in Fig. 11, the operating surface 121 of the first housing 120 and the display surface 131 of the second housing 130 are exposed in the substantially the same direction, so that the user can manipulate the operating keys 122 and 123 provided to the operating surface 121 of the first housing 120, and simultaneously, can see the liquid crystal display unit 132 provided to the display surface 131 of the second housing 130.

[0047] In the folded-back state illustrated in Fig. 12, the other surface of the second housing 130 is allowed to overlap with the operating surface 121 of the first housing 120, so that the operating surface 121 of the first housing 120 is not exposed, and the display surface 131 of the second housing 130 overlapping with the first housing 120 is exposed. In this state, the user can see the liquid crystal display unit 132 provided to the display surface 131 of the second housing 130.

[0048] Specifically, in the closed state illustrated in Fig. 10, the liquid crystal display 132 of the second housing 130 face the first housing 120, and a display surface of the liquid crystal display unit 132 is externally invisible. On the other hand, in the use state illustrated in Fig. 11 and the folded-back state illustrated in Fig. 12, the display surface of the liquid crystal display unit 132 of the second housing 130 is exposed, and the display surface is externally visible. Therefore, the user may allow the mobile phone 110 to be in the use state illustrated in Fig. 11 or in the folded-back state illustrated in Fig. 12 to watch information such as images of the television broadcasting displayed on the liquid crystal display unit 132.

[0049] The antenna module 40 is provided to an end portion opposite to the other end portion provided with the hinge 111 in the second housing 130 to receive television broadcasting. The antenna module 40 is separately provided from an antenna module (not shown) for phone calls. The antenna module for phone calls, for example, is included in the first housing 120 to be adjacent to the hinge 111. As described above, the antenna module 40 for receiving television broadcasting and the antenna module for phone calls are separated as much as possible from each other to prevent interference therebetween.

[0050] As illustrated in Figs. 10A, 11A, and 12B, the first housing 120 of the mobile phone 110 includes two magnetic induction type sensors 71 and 72 for detecting magnetism. The first sensor 71 is provided to a lower right corner of the first housing 120 in the figure, and the second sensor 72 is provided to a lower left corner of the first housing 120 in the figure.

[0051] On the other hand, as illustrated in Fig. 11A, a magnet 75 is fixed to an upper right corner of the second housing 130 with respect to the display surface 131 in-

cluding the liquid crystal display unit 132. Accordingly, when the first and second housings 120 and 130 are in the closed state as illustrated in Fig. 10, the magnet 75 is close to the sensor 71. On the contrary, when the first and second housings 120 and 130 are in the use state as illustrated in Fig. 11, the magnet 75 and the sensors 71 and 72 are separated from each other. In addition, in the folded-back state in which the display surface 131 is exposed as illustrated in Fig. 12, the magnet 75 and the sensor 72 are close to each other. The sensors 71 and 72 acquire different outputs according to distances from the magnet 75. Therefore, a detecting signal output in the closed state illustrated in Fig. 10 and a detecting signal output in the use state illustrated in Fig. 11 have different levels from each other, and a detecting signal output in the closed state illustrated in Fig. 10 and a detecting signal output in the folded-back state illustrated in Fig. 11 have different levels from each other.

[0052] Accordingly, according to a combination of the signal levels of the detecting signals of the first and second sensors 71 and 72, the state (the closed state, the use state, or the folded-back state) of the first and second housings 120 and 130 can be determined. As illustrated in Fig. 13 in which like reference numerals in Fig. 6 denote like elements, the control circuit 63 stores correspondence between the combination of the signal levels of the detecting signals S71 and S72 of the first and second sensor 71 and 72, respectively, and the state (the closed state, the use state, or the folded-back state) of the housings of the mobile phone 110 in the form of a correspondence table, and determines the state of the housings of the mobile phone 110 by referring to the correspondence table on the basis of the detecting signals S71 and S72 supplied from the first and second sensor 71 and 72, respectively.

[0053] In addition, the control circuit 63 transmits an indicating signal for indicating a tuning voltage according to the closed state, the use state, or the folded-back state on the basis of each signal level of the detecting signals S71 and S72 output from the sensors 71 and 72, respectively, to the demodulation IC 62. The demodulation IC 62 supplies the tuning voltage V_{tune} according to the indicating signal obtained from the control circuit 63 to the matching circuit 40b (see Figs. 4 and 5) of the antenna module 40.

[0054] Specifically, as illustrated in Fig. 14, the control circuit 63 sets the tuning voltage V_{tune1} use in the closed state, the tuning voltage V_{tune2} use in the use state, and the tuning voltage V_{tune3} used in the folded-back state for each channel of television broadcasting in the form of the correspondence table. In addition, on the basis of the signal levels of the detecting signals obtained from the sensors 71 and 72, the control circuit 63 selects one from among the tuning voltages V_{tune1}, V_{tune2}, and V_{tune3} used in the closed state, the use state, and the folded-back state, respectively, and transmits an indicating signal for indicating the selected tuning voltage to the demodulation IC 62.

[0055] For example, when the user selects, for example, a channel CH1 by manipulating the operating keys 122 and 123, the control circuit 63 determines whether the housings are in the closed state, the use state, or the folded-back state on the basis of the detecting signals received from the sensors 71 and 72. When the housings are in the closed state, the control circuit 63 selects the tuning voltage V_{tune1} (=1.4 V) used in the closed state corresponding to the channel CH1 and transmits the indicating signal indicating the selected tuning voltage to the demodulation IC 62. When the housings are in the folded-back state, the control circuit 63 selects the tuning voltage V_{tune3} (=1.2 V) used in the folded-back state corresponding to the channel CH1, and when the housings are in the use state, the control circuit 63 selects the tuning voltage V_{tune2} (=1.0 V) used in the use state corresponding to the channel CH1. The control circuit 63 then transmits the indicating signal indicating the selected tuning voltage to the demodulation IC 62.

[0056] The demodulation IC 62 transmits the tuning voltage V_{tune} indicated by the indicating signal received from the control circuit 63 to the matching circuit 40b of the antenna module 40.

[0057] Accordingly, the optimal tuning voltage according to the state (the closed state, the use state, or the folded-back state) of the housings of the mobile phone 10 can be supplied to the antenna module 40. In particular, in the closed state (see Fig. 10), the display surface 131 faces the first housing 120, and the liquid crystal display unit 132 is not externally visible. However, in some cases, as illustrated in Fig. 10A, for example, a relatively smaller liquid crystal display unit 142 may be provided to the other surface of the second housing 130 to receive and display the television broadcasting and the like. Even in this case, the optimal tuning voltage needs to be set according to the state of the first and second housings 120 and 130.

[0058] According to the embodiment, selecting the optimal tuning voltage according to the states (the closed state, the use state, and the folded-back state) of the housings illustrated in Figs. 10 to 12 is described. However, the states of the housings are not limited thereto. For example, as illustrated in Fig. 15, the second housing 130 rotates in the horizontal direction with respect to the first housing 120 so that the liquid crystal display unit 132 displays images of the television broadcasting in a horizontally long state (hereinafter, referred to as horizontally long display state). In this case, as sensing means for detecting the horizontally long display state, for example, a second magnet 76 is provided to the second housing 130, and a third sensor 73 is provided to a position of the first housing 120 corresponding to the position of the second magnet 76 in the horizontally long display state illustrated in Fig. 15, so as to determine the horizontally long display state according to the output of the third sensor 73.

[0059] Accordingly, the mobile phone 110 according to the embodiment described above can select the opti-

mal tuning voltage according to the state of the housings and receive the television broadcasting.

Another embodiment

[0060] In the aforementioned embodiments, the mobile phone receiving the television broadcasting is described. However, the invention is not limited thereto, and the invention may be applied to various types of mobile phones such as PDAs (personal digital assistants) having a function of receiving television broadcasting.

[0061] The invention is applicable to mobile devices such as mobile phones having the function of receiving television broadcasting.

[0062] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims of the equivalents thereof.

Claims

1. A mobile device having first and second housings of which positional relationship is variable, comprising:

in the first and second housings,
an antenna element for receiving television signals;
a matching circuit including a variable capacitance element to perform matching with the antenna element;
a television signal receiver circuit connected to the matching circuit;
a control circuit controlling a tuning voltage to be supplied to the variable capacitance element; and
a sensing unit detecting the positional relationship between the first and second housings,

wherein the control circuit controls the tuning voltage according to the positional relationship between the first and second housings represented by the detection result of the sensing unit.

2. The mobile device according to claim 1, wherein at least one of the first and second housings includes a display for displaying images demodulated from the received television signal.

3. The mobile device according to claim 1 or 2, wherein the control circuit includes a storage unit storing a correspondence table representing correspondence between the positional relationship of the first and second housings and the tuning voltage.

4. The mobile device according to one of claims 1 to 3, wherein the sensing unit includes a magnet provided to at least one of the first and second housings and a magnetism sensor provided to the other one of the first and second housings.

FIG. 1A

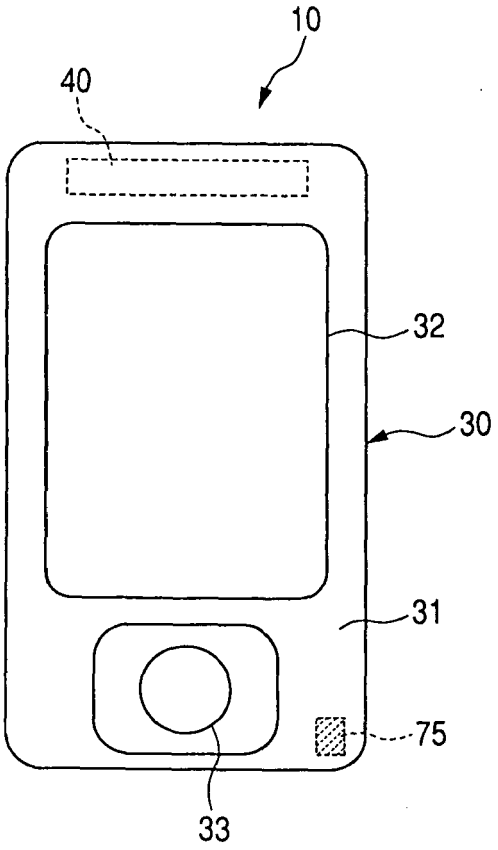


FIG. 1B

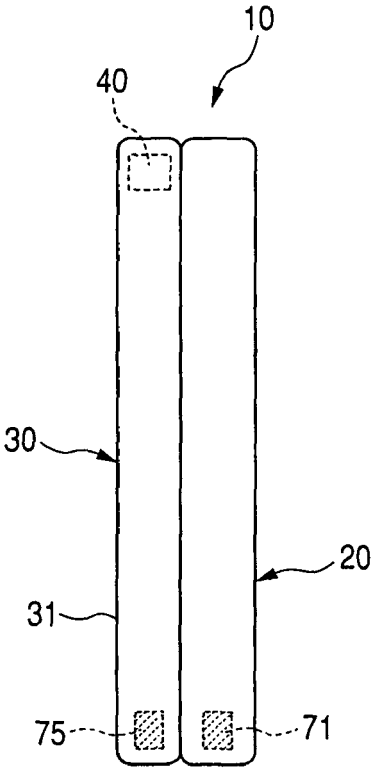


FIG. 2A

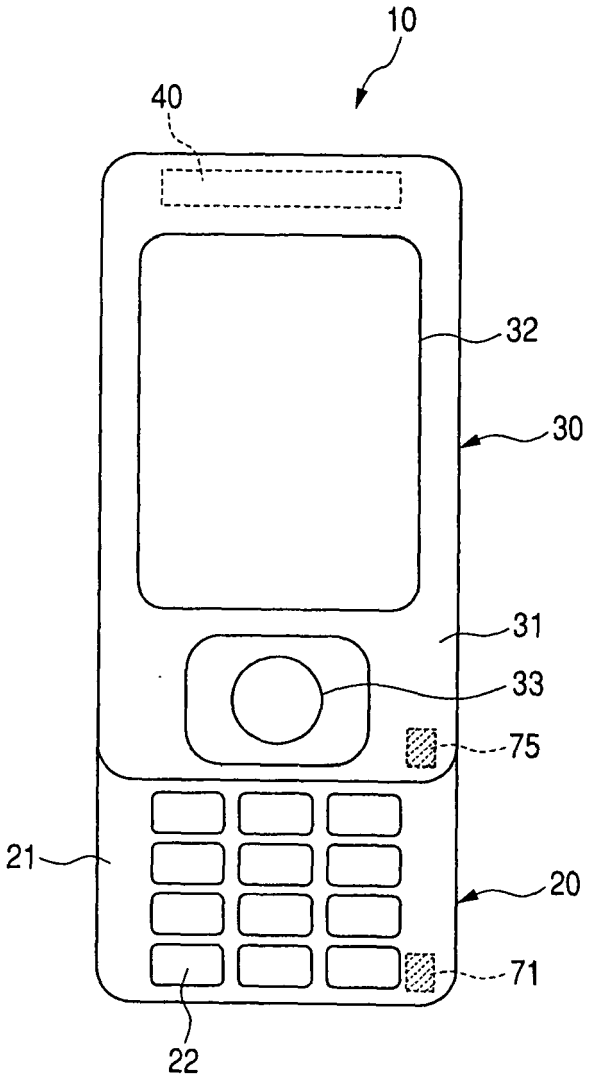


FIG. 2B

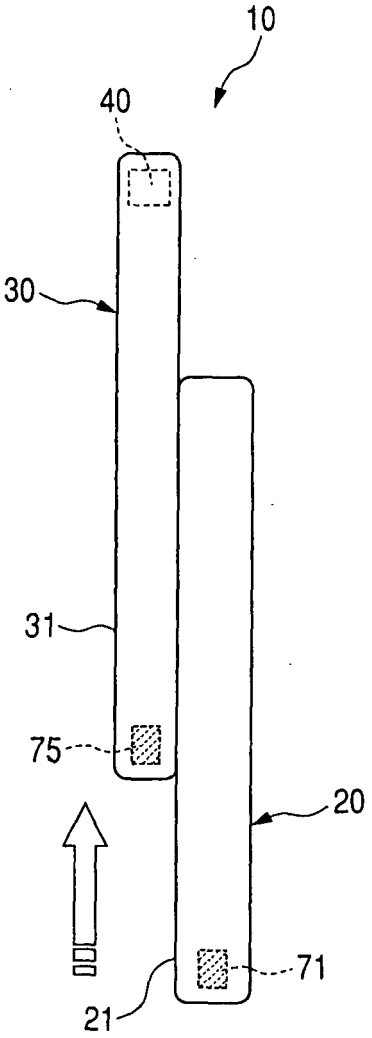


FIG. 3

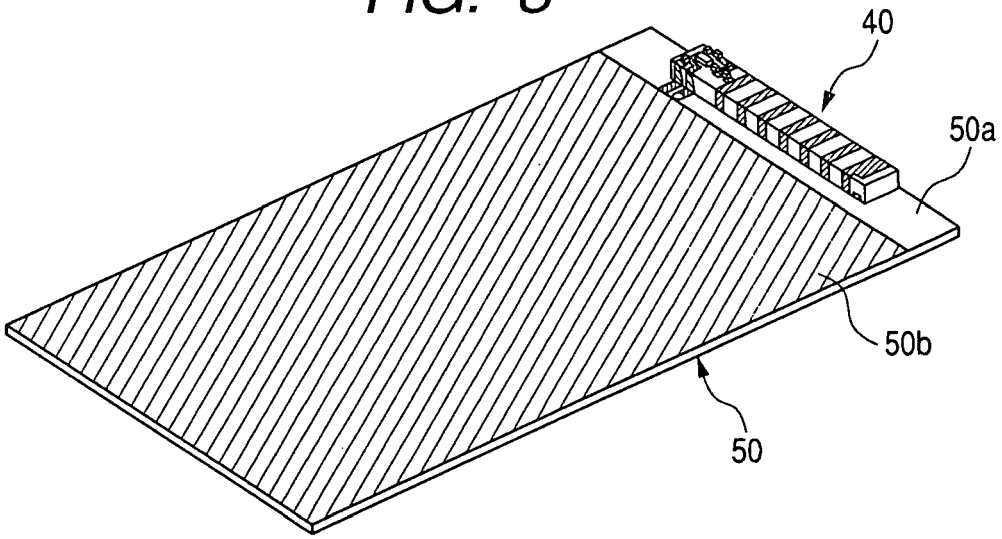


FIG. 4

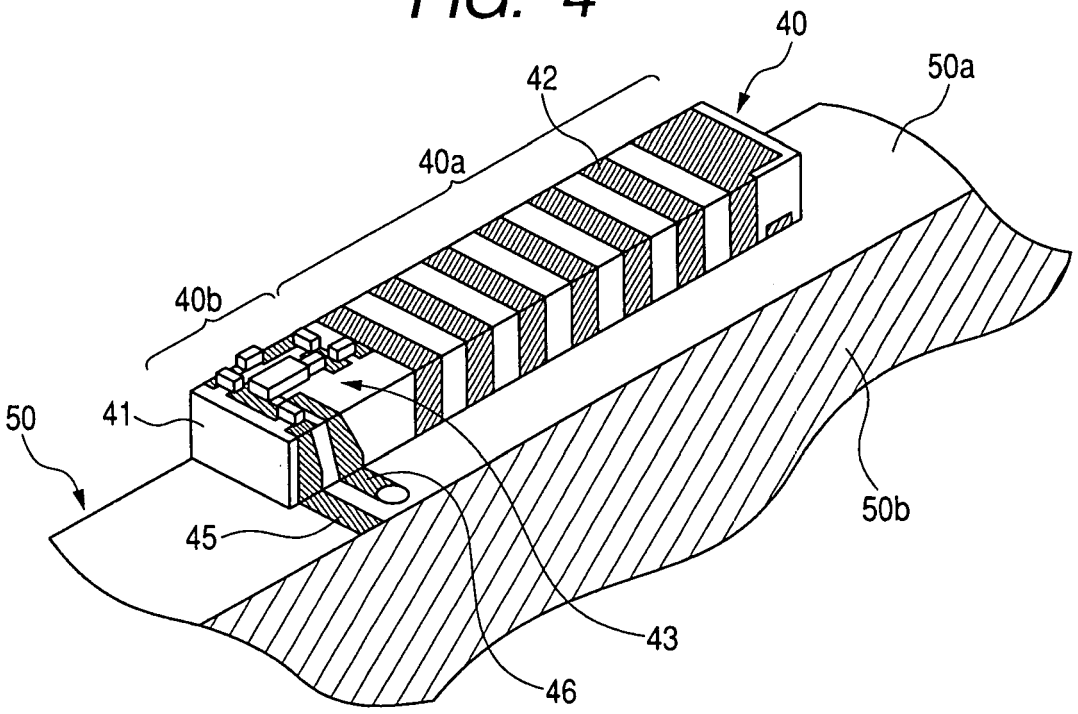


FIG. 5

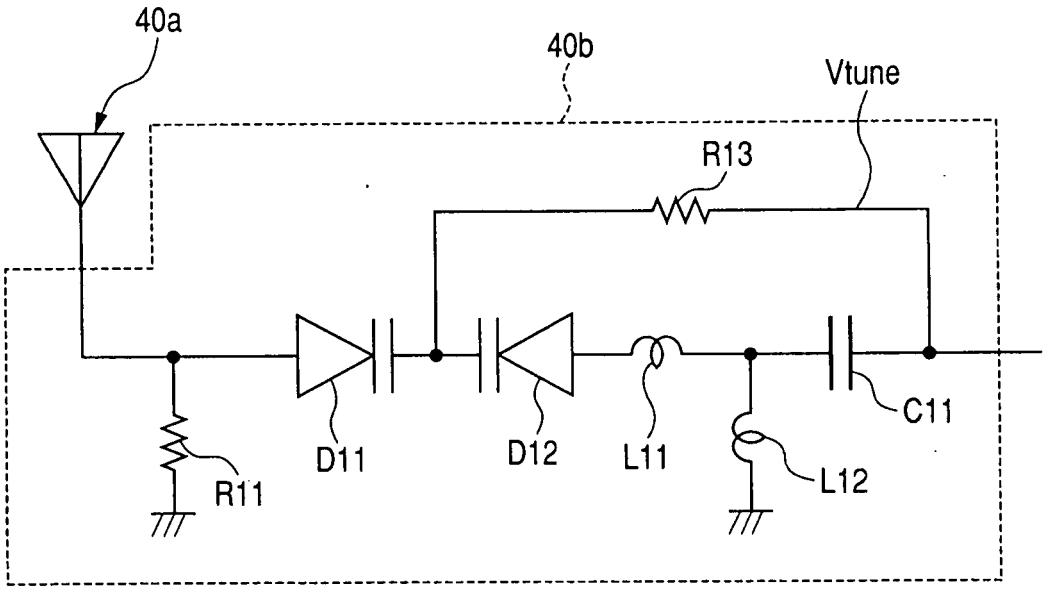


FIG. 6

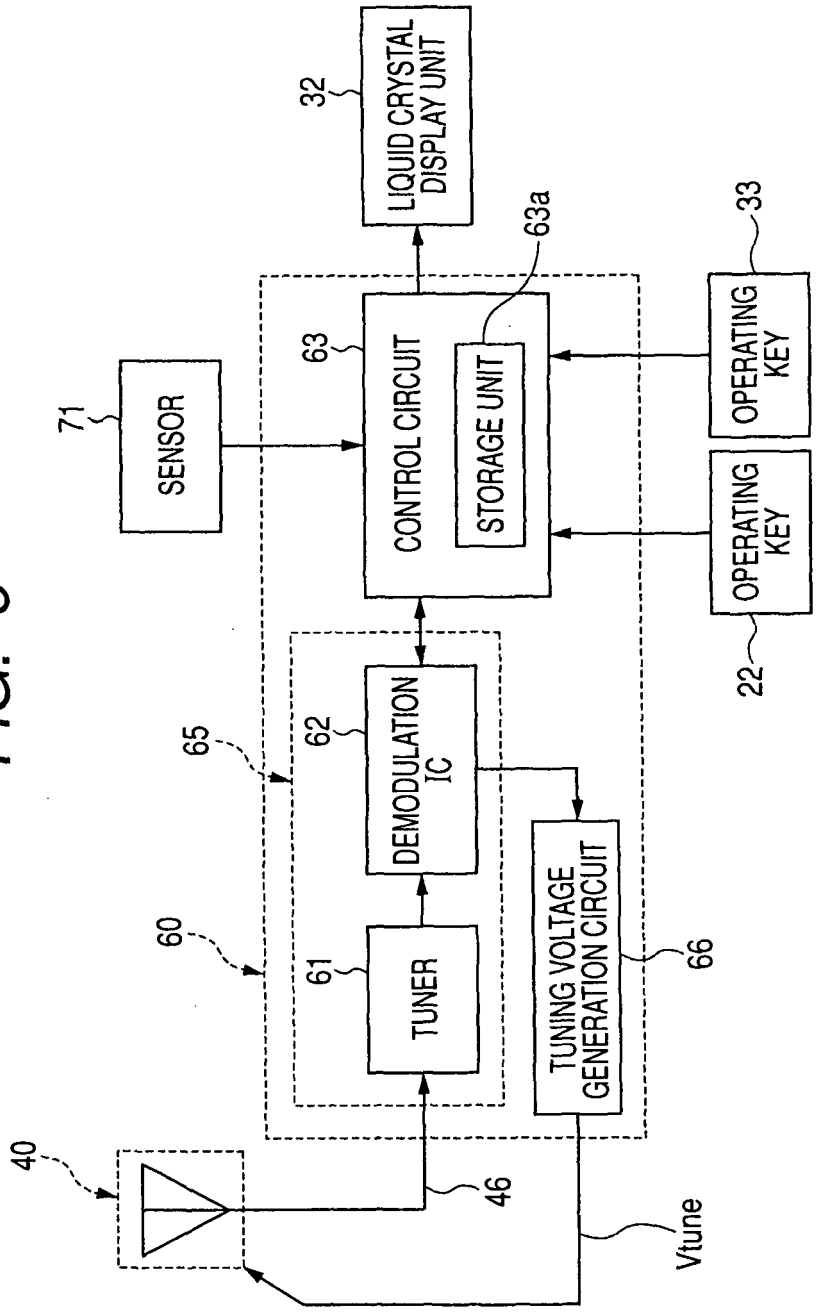

LIQUID CRYSTAL DISPLAY UNIT
32
63a
33
OPERATING KEY
SENSOR
71
63
CONTROL CIRCUIT
STORAGE UNIT
OPERATING KEY
22
65
62
DEMODULATION IC
60
61
TUNER
TUNING VOLTAGE GENERATION CIRCUIT
66
40
46
Vtune

FIG. 7

CHANNEL	Vtune1	Vtune2
CH1	1.4 [V]	1.0 [V]
CH2	1.5 [V]	1.1 [V]
⋮	⋮	⋮

FIG. 8

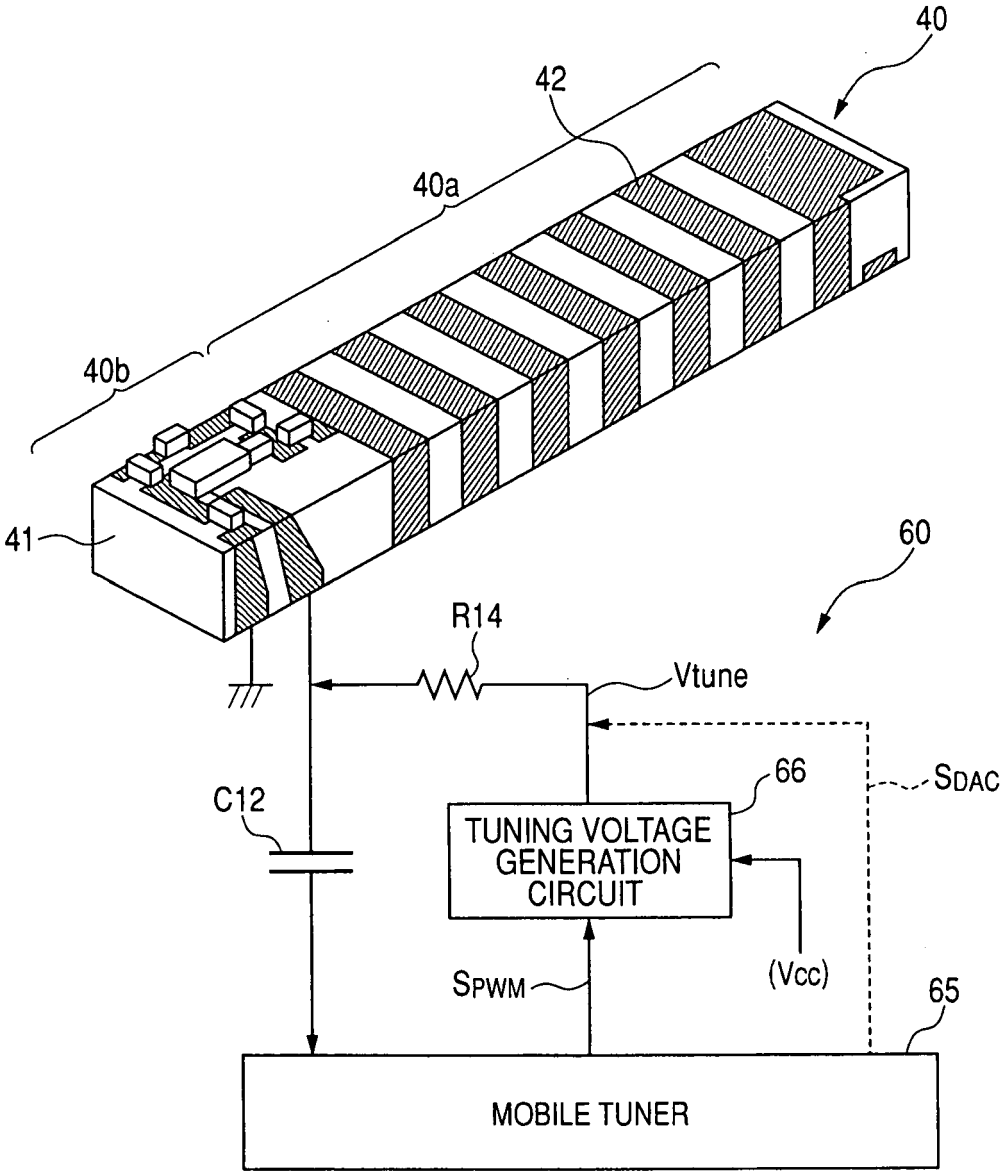

40
42
40a
40b
41
60
R14
Vtune
C12
66
SDAC
TUNING VOLTAGE GENERATION CIRCUIT
SPWM
(Vcc)
65
MOBILE TUNER

FIG. 9

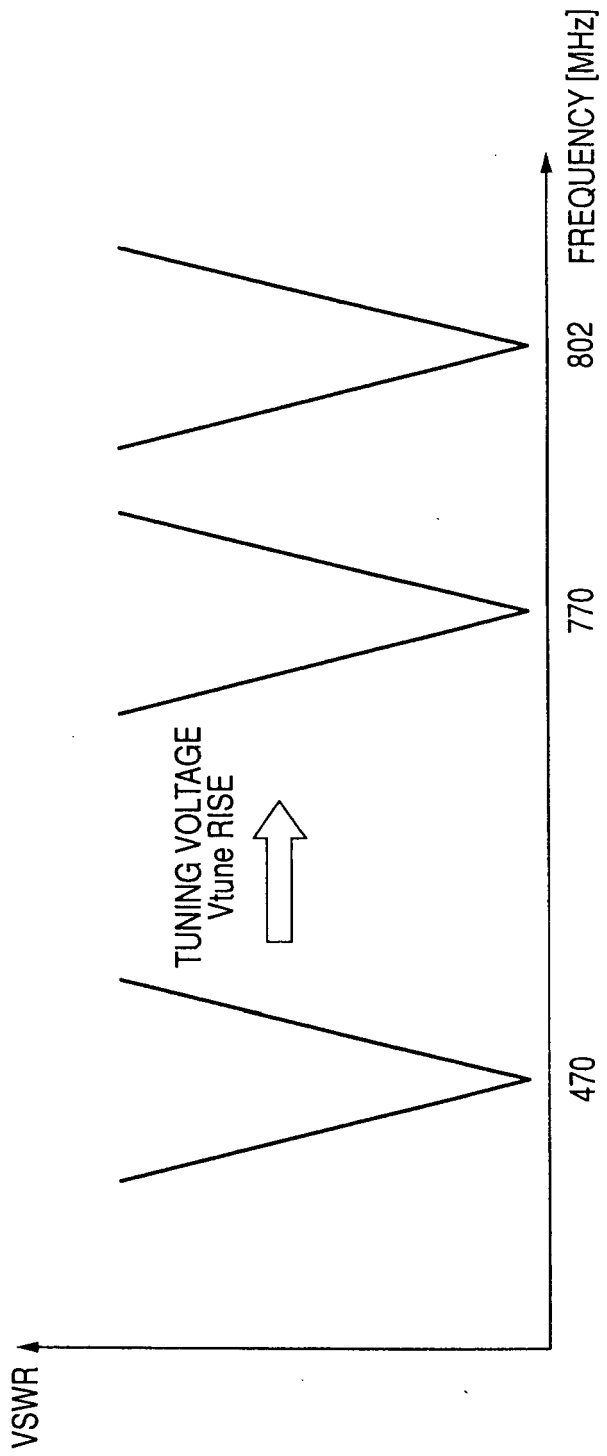


FIG. 10A

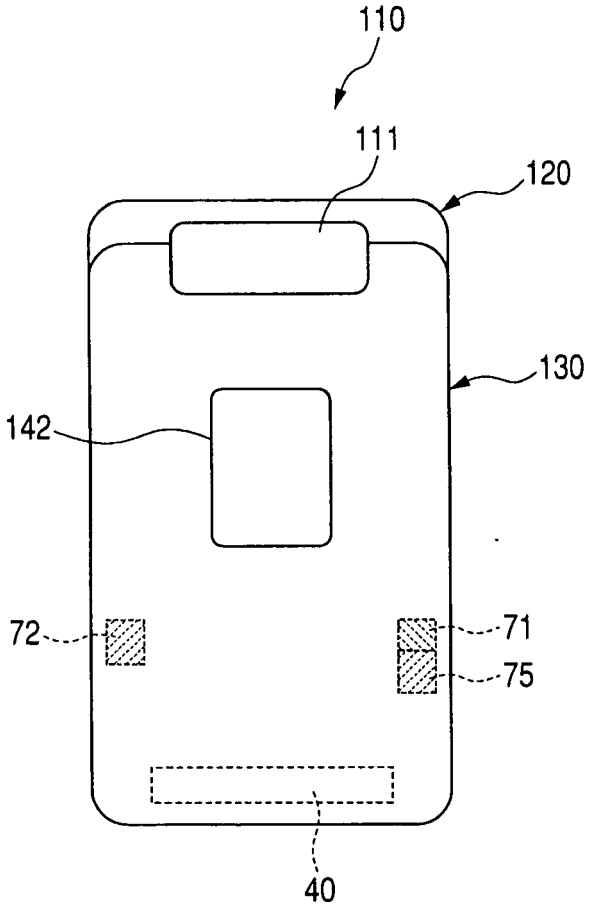


FIG. 10B

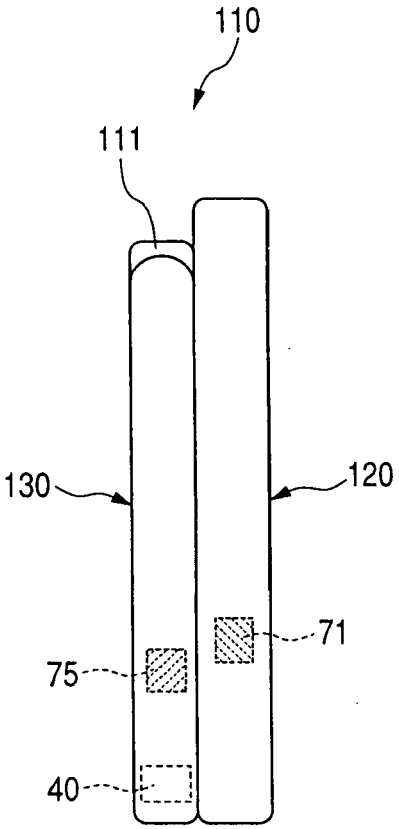


FIG. 11A

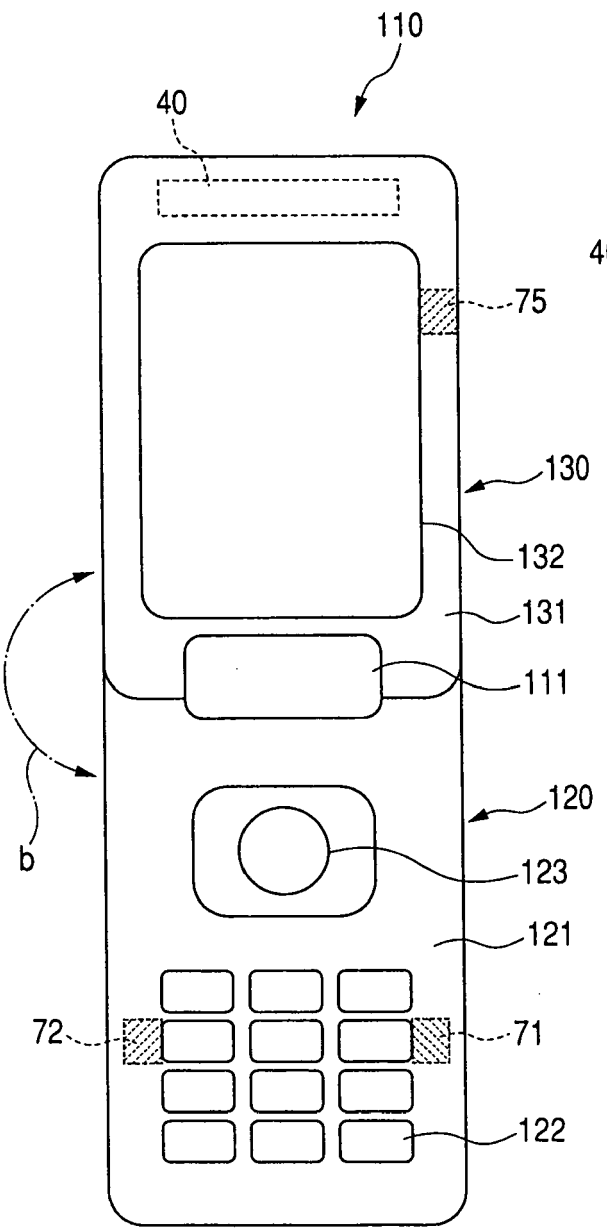


FIG. 11B

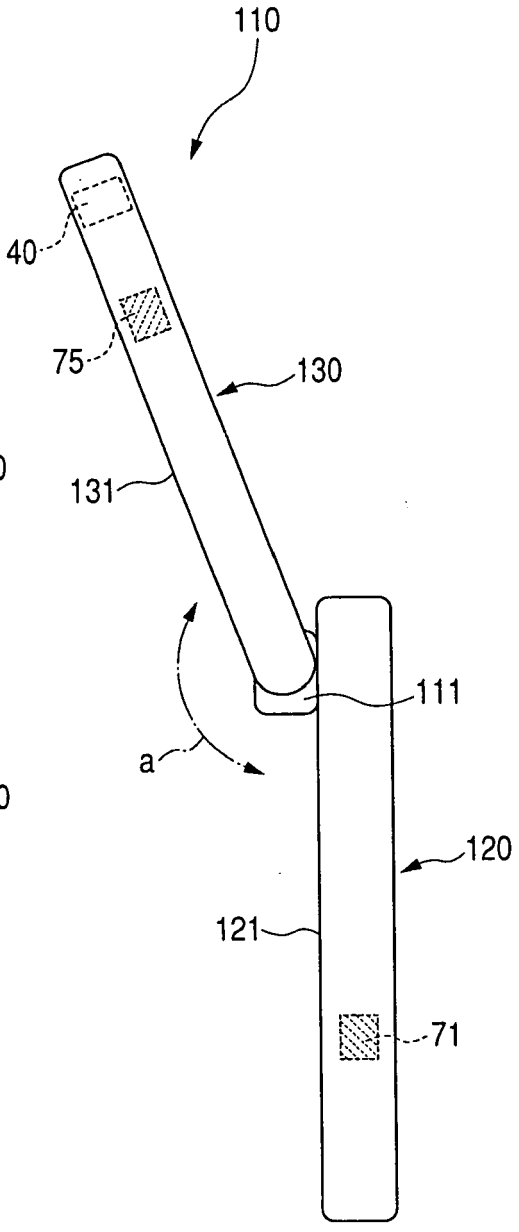


FIG. 12A

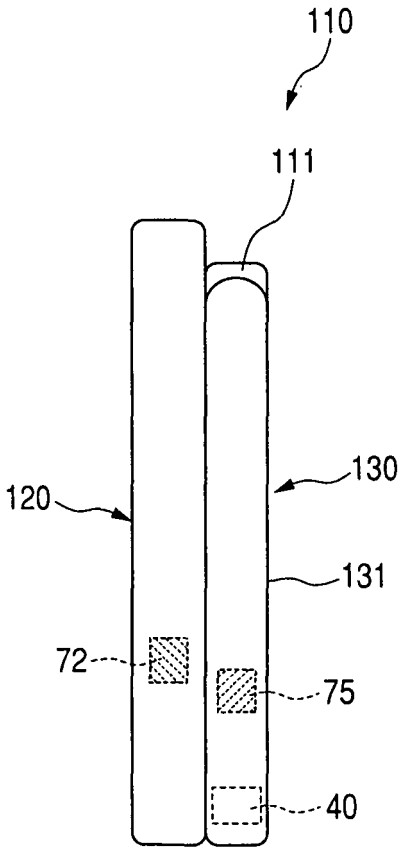


FIG. 12B

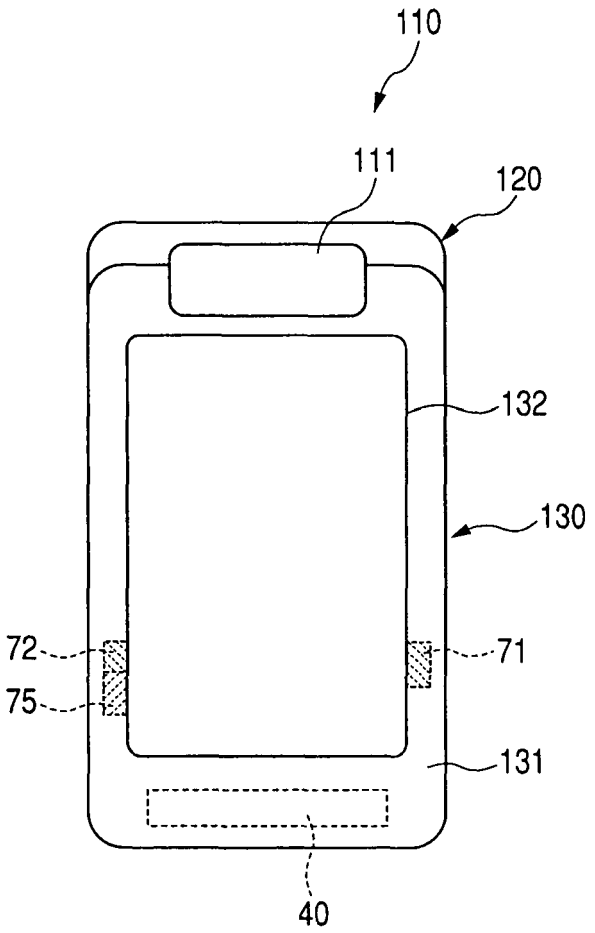


FIG. 13

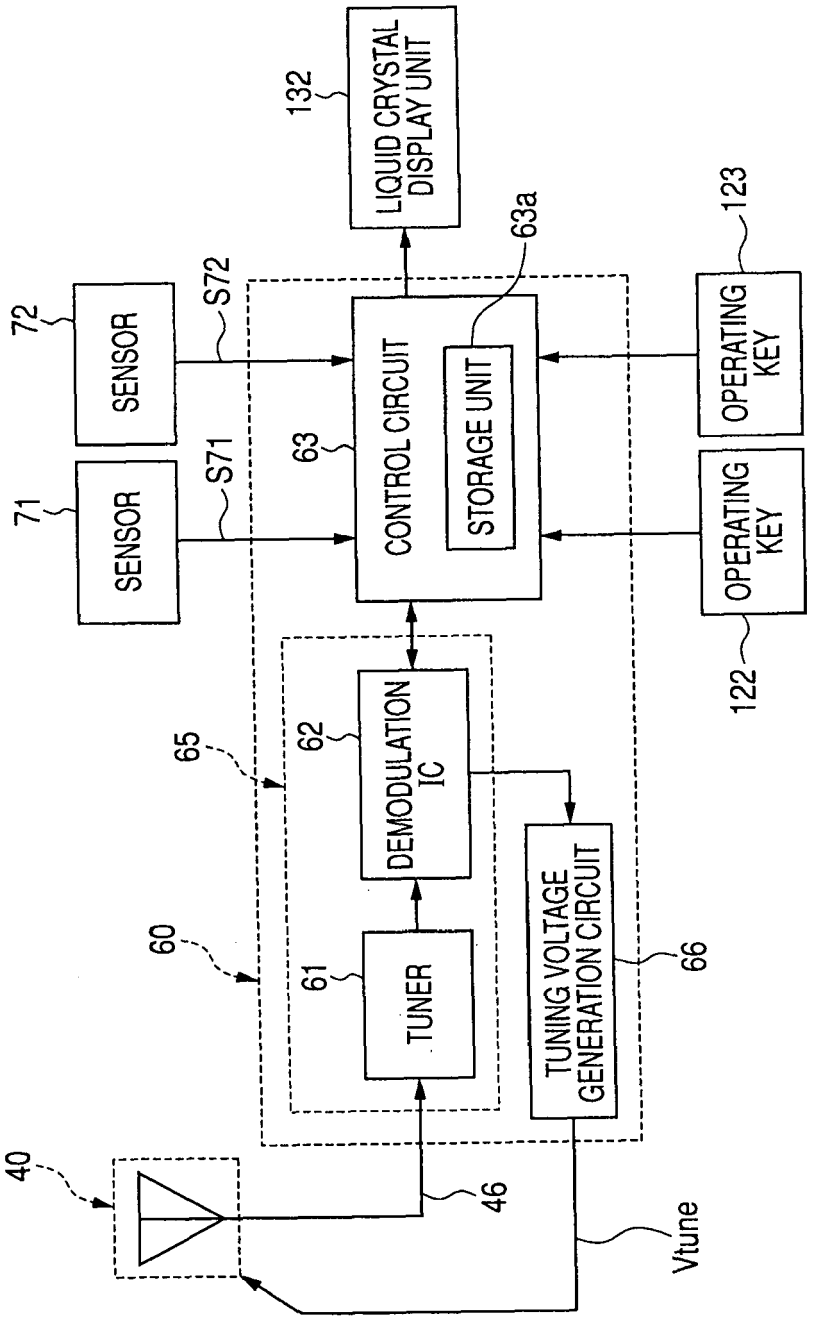
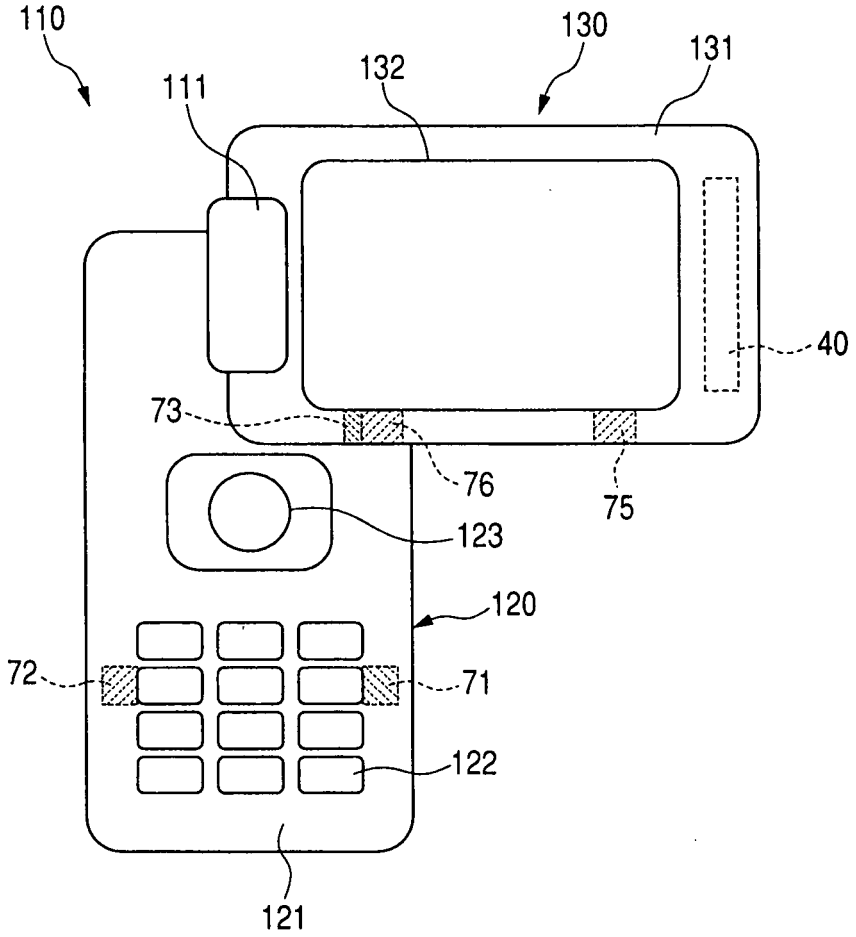

LIQUID CRYSTAL DISPLAY UNIT
132
SENSOR
72
S72
SENSOR
71
S71
CONTROL CIRCUIT
63
STORAGE UNIT
63a
OPERATING KEY
123
OPERATING KEY
122
65
DEMODULATION IC
62
60
TUNER
61
TUNING VOLTAGE GENERATION CIRCUIT
66
40
46
Vtune

FIG. 14

CHANNEL	Vtune1	Vtune2	Vtune3
CH1	1.4 [V]	1.0 [V]	1.2 [V]
CH2	1.5 [V]	1.1 [V]	1.3 [V]
⋮	⋮	⋮	⋮

FIG. 15



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EUROPEAN SEARCH REPORT

Application Number
EP 08 02 0643

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 1 538 694 A (MATSUSHITA ELECTRIC IND CO LTD [JP]) 8 June 2005 (2005-06-08) * abstract; figure 12 * * paragraphs [0106] - [0113] *	1-4	INV. H01Q1/24
Y	EP 1 258 943 A (MITSUBISHI ELECTRIC CORP [JP]) 20 November 2002 (2002-11-20) * abstract; figure 12 * * paragraphs [0033] - [0035] *	1-4	
Y	EP 1 655 850 A (MATSUSHITA ELECTRIC IND CO LTD [JP]) 10 May 2006 (2006-05-10) * paragraphs [0011] - [0020]; figure 3 *	1-4	
A	US 2005/255818 A1 (WATABE NOBUYA [JP]) 17 November 2005 (2005-11-17) * abstract; figures 1-3 * * paragraphs [0007] - [0009] * * paragraphs [0021] - [0032] *	1-4	
A	EP 1 557 902 A (ALPS ELECTRIC CO LTD [JP]) 27 July 2005 (2005-07-27) * abstract; figures 1,2 * * paragraphs [0020] - [0026] *	1-4	TECHNICAL FIELDS SEARCHED (IPC) H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 February 2009	Unterberger, Michael

CATEGORY OF CITED DOCUMENTS

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16-02-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1538694 A	08-06-2005	AU 2003281595 A1	09-02-2004
		CN 1682405 A	12-10-2005
		WO 2004010530 A1	29-01-2004
EP 1258943 A	20-11-2002	CN 1384611 A	11-12-2002
		JP 3830773 B2	11-10-2006
		JP 2002335180 A	22-11-2002
		US 2002169010 A1	14-11-2002
EP 1655850 A	10-05-2006	CN 1830154 A	06-09-2006
		JP 3931163 B2	13-06-2007
		JP 2005064948 A	10-03-2005
		WO 2005018101 A1	24-02-2005
		US 2007010217 A1	11-01-2007
US 2005255818 A1	17-11-2005	JP 2005328192 A	24-11-2005
EP 1557902 A	27-07-2005	DE 602005002567 T2	26-06-2008
		JP 2005210564 A	04-08-2005
		KR 20050077026 A	29-07-2005
		US 2005162323 A1	28-07-2005

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Patent documents cited in the description

- JP 2007314546 A **[0001]**
- JP 2006041840 A **[0003]**
- JP 2006332795 A **[0004]**