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(54) **Title**: AN ECHO CANCELLATION DEVICE FOR A 2-WIRE INTERCOM SYSTEM AND A METHOD THEREOF

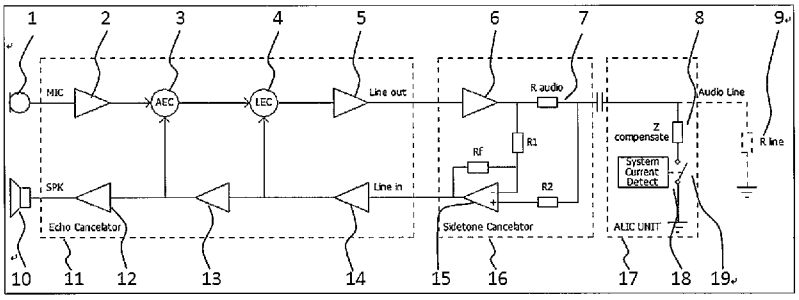


Fig.2

(57) **Abstract**: The present invention discloses an echo cancellation device for a 2-wire intercom system and a method thereof. The echo cancellation device comprises: an echo cancellation circuit (11), configured to eliminate the acoustic echo caused by the feedback of the audio signal reflected from the local speaker into local microphone and the line echo caused by the impedance mismatch of the line-side tone cancellation circuit. The solutions proposed in the invention are beneficial to modularize the audio circuit and improve the assembly process for a better design with beautiful profile as well as the speech quality and system reliability.

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AN ECHO CANCELLATION DEVICE FOR A 2-WIRE INTERCOM SYSTEM AND A METHOD

FIELD OF THE INVENTION

The invention relates to the intercom system technical field, and more particularly to an echo cancellation device for a 2-wire intercom system and a method thereof.

BACKGROUND OF THE INVENTION

In the existing two-wire intercom system, a so called sidetone cancellation circuit (i.e. two-four line conversion circuit) was adopted during transmitting the bidirectional audio signal in the two-wire bus. To achieve hand-free calls between two sides, the half-duplex and full-duplex mode were commonly used to transmit such audio signal.

In the half-duplex mode, only the audio signal of one speaker can be transmitted simultaneously. If the voice volume of the person or the background noise at the far terminal becomes larger than the one speaks at the local terminal, the speech at the local terminal may be interrupted; even it will lead to a seriously intermittent communication.

In the full-duplex mode, the echo cancellation technology is used to achieve a full-duplex hand-free intercom. However, when large numbers of terminal devices change, it may lead to a serious audio impedance mismatch which will be greatly beyond the dynamically adjustable range of the line echo cancellation circuit; therefore, the system may occur large echo issues, even make the communication intermitted. In the beginning of the installation of the intercom system and debugging operation as well, the appropriate impedance shall be manually configured to match the network according to the load of the actual bus, which makes the engineering construction more complicated and error-prone.

Consequently, existing solutions including the prior art mentioned above

can't provide a suitable echo cancellation technology to improve the communication for a two-wire intercom system. Due to the above mentioned problems, the present invention is to propose an echo cancellation device for a 2-wire intercom system and a method thereof.

SUMMARY OF THE INVENTION

The main object of the present invention is to eliminate the acoustic echo caused by the feedback of the audio signal reflected from the local speaker into local microphone. Hence, the present invention provides an echo cancellation device for a 2-wire intercom system and a method thereof.

Furthermore, another object of the present invention is to eliminate the line echo caused by the impedance mismatch of the line-side tone cancellation circuit i.e. two-four line conversion circuit.

The further object of the present invention is to eliminate the line echo caused by the line impedance mismatch when the quantity of terminal devices changes.

According to an aspect of the present invention, it provides an echo cancellation device for a 2-wire intercom system. The echo cancellation device comprises: an echo cancellation circuit, configured to eliminate the acoustic echo caused by the feedback of the audio signal reflected from the local speaker into local microphone and the line echo caused by the impedance mismatch of the line-side tone cancellation circuit.

According to another preferred embodiment of the present invention, the echo cancellation device further comprises a sidetone cancellation circuit, configured to eliminate sidetone echo caused by the mismatch of the line impedance R_{line}.

According to another preferred embodiment of the present invention, the line impedance further comprises the audio impedance of the far end device, other standby devices connected to the 2-wire system bus and the audio impedance of system power supply.

According to another preferred embodiment of the present invention, the echo cancellation device further comprises an automatic line impedance

compensation circuit, configured to eliminate the line echo caused by the line impedance mismatch when the quantity of terminal devices changes.

According to another preferred embodiment of the present invention, the Echo cancellation circuit further comprises: a microphone amplifier, an acoustic echo canceller, a line echo canceller and a line output amplifier connected in sequence between a local microphone and a sidetone cancellation circuit; and at least a line output amplifier and a speaker amplifier connected in sequence between the sidetone cancellation circuit and a local speaker.

According to another preferred embodiment of the present invention, the outputs of the at least a line output amplifier are input to the acoustic echo canceller and the line echo canceller individually.

According to another preferred embodiment of the present invention, the sidetone cancellation circuit further comprises: an operational amplifier, a line driver amplifier and an audio source terminal resistor connected in sequence between the echo cancellation circuit and an automatic line impedance compensation circuit.

According to another preferred embodiment of the present invention, the automatic line impedance compensation circuit further comprises: a compensation resistor network, a system current detection circuit 18 and a compensation switch.

According to another preferred embodiment of the present invention, the system current detection circuit 18 further comprises: a power supply, a power load RL , a sampling resister $R_{sampling}$ and a control unit MCU; in which the RL is the whole load of all devices connected to the system.

According to another preferred embodiment of the present invention, the MCU is configured to detect the system current and convert it into the impedance of audio by using a sampling resister $R_{sampling}$, and then control the switch of the compensation resistor network.

According to another preferred embodiment of the present invention, the echo cancellation device further comprises a line resistor, configured to equal to the impedance of the far end terminal device in audio line.

According to the other aspect of the present invention, it provides an echo cancellation method for a 2-wire intercom system. The method is implemented by any one of the echo cancellation devices mentioned above.

Embodiments of the present invention provide an echo cancellation device for a 2-wire intercom system and a method thereof, which achieves high quality speech and system reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter of the invention will be explained in more details in the following description with reference to preferred exemplary embodiments which are illustrated in the drawings, in which:

Fig.1 illustrates an echo cancellation device for a 2-wire intercom system to according to an embodiment of the present invention;

Fig.2 illustrates a circuit diagram of an echo cancellation device for a 2-wire intercom system to according to a preferred embodiment of the present invention; and

Fig.3 illustrates a circuit diagram of the system current detection circuit according to an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Exemplary embodiments of the present invention are described in conjunction with the accompanying drawings hereinafter. For the sake of clarity and conciseness, not all the features of actual implementations are described in the specification.

The present invention provides an echo cancellation device for a 2-wire intercom system to achieve a high-quality full-duplex hand-free speech between two sides and a simplified construction process as well as the improved system stability.

Fig.1 illustrates an echo cancellation device for a 2-wire intercom system to according to an embodiment of the present invention.

As shown in Fig.1, an echo cancellation device 100 for a 2-wire intercom system comprises at least an echo cancellation circuit 11, a sidetone cancellation circuit 16 and an automatic line impedance compensation circuit (ALIC) 17.

In which, the echo cancellation circuit 11 is configured to eliminate the acoustic echo caused by the feedback of the audio signal reflected from the local speaker into local microphone and the line echo caused by the impedance mismatch of the line-side tone cancellation circuit.

The sidetone cancellation circuit 16 is configured to eliminate sidetone echo caused by the mismatch of the line impedance, for example, the audio impedance of the far end device, other standby devices connected to the 2-wire system bus and the audio impedance of system power supply.

The automatic line impedance compensation circuit 17 is configured to eliminate the line echo caused by the line impedance mismatch when the quantity of terminal devices changes.

Fig.2 illustrates a circuit diagram of an echo cancellation device for a 2-wire intercom system to according to a preferred embodiment of the present invention.

As shown in Fig.2, the echo cancellation circuit 11 further comprises: a microphone 1, a microphone amplifier 2, an acoustic echo canceller 3, a line echo canceller 4 and a line output amplifier 5 connected in sequence; and at least a line output amplifier 13, 14 and a speaker amplifier 12 connected in sequence between the sidetone cancellation circuit 16 and a local speaker 10.

The output of the line output amplifier 5 is connected to the sidetone cancellation circuit 16; and the output of the sidetone cancellation circuit 16 is connected to the line output amplifier 14. What's more, the outputs of the line output amplifier 13, 14 are input to the acoustic echo canceller 3 and the line echo canceller 4 individually.

The sidetone cancellation circuit 16 further comprises: an operational amplifier 15, a line driver amplifier 6 and an audio source terminal resistor R_{audio} 7 connected in sequence between the echo cancellation circuit 11 and an automatic line impedance compensation circuit 17.

The automatic line impedance compensation circuit 17 further comprises: a compensation resistor network 8, a system current detection circuit 18 and a compensation switch 19.

In detail, the near end of the microphone 1 picks up the near end speech signal, which will be amplified by the microchip amplifier 2; and the signal goes through the AEC 3 and LEC 4, and then is amplified by the line output amplifier

5 and sent to the sidetone cancellation circuit 16. When the line drive amplifier 6 of the sidetone cancellation circuit 16 receives the signal, the signal goes through the audio source terminal resistance R_{audio} 7 to the two-wire bus.

AEC 3 is used to eliminate the acoustic echo. AEC circuit performs a DSP operation following a certain regulation based on a mixed signal and the signal from the input end of speaker amplifier 12 to eliminate the acoustic echo signal, and output a clear signal to the back end circuit; in which the mixed signal consists of the proximal signal picked up from the near end of the microphone 1 and acoustic echo signal. LEC 4 further eliminates the line echo signal, and then outputs a clean signal to the line.

There is a same audio circuit formed by an echo cancellation circuit 11 and a sidetone cancellation circuit 16 over the far end of the system. When the near end audio circuit receives the signal sent by far end audio circuit, the signal goes through the sidetone cancellation circuit 16, which is amplified by the amplifier 15 and sent to the echo cancellation circuit 11, and then the signal goes through the amplifier 14 and 13, and is driven by audio power amplifier 12 to speaker 10.

The sidetone cancellation circuit 16 ensures that the microphone picks up the audio signal and sends it to the bus, also eliminates the signal which feeds back to the near speaker from the near end microphone. And the circuit can achieve a full-duplex talk between near end and far end in two-wire bus. The signal picked up by near end microphone has two parts: one is the signal picked up by near end microphone, the other is the acoustic echo signal generated by near end speak sound feedback to the near end microphone from space.

The operational amplifier 15 is individually input the signals from left hand and right hand of R_{audio} 7. The signal of near end microphone 1 goes through the echo cancelation circuit 11 and the line driver amplifier 6, and passes through R_{audio} 7. The signal from left hand of R_{audio} is twice as from right hand, and they have same phase. The output of operational amplifier 15 will be 0V if $R1/Rf = R_{audio}/R_{line}$. The signal from near end microphone is cancelled by operational amplifier 15.

On the other hand, the audio signal from the far end of the system goes through R_{audio}, the signal from left hand of R_{audio} is zero, and the signal from right hand of R_{audio} does not equal zero. The output of the operational amplifier

15 will be (1+ R1/Rf) times of the input signal from right hand of R_{audio}. The signal from the far end microphone is separated and enlarged by operational amplifier 15.

To keep the sidetone cancelation circuit 16 work well, the ratio of the audio source terminal resistor R_{audio} 7 to the line resistor R_{line} 9 shall equal to the ratio of R1/Rf. In practice, line resistor depends on multiple factors: audio impedance of far end device in a communication, audio impedance of the idle terminal devices connected in a 2-wire intercom system in parallel, audio impedance of the power supply for system. The number of devices connected to the system in parallel is unknown in advance and real-time changed, so the impedance of the power supply varies with the change of the output load current. Hence, the line resistor R_{line} 9 is inconstant which causes the impedance of sidetone cancelation circuit unmatched. The unmatched impedance will cause a line echo, i.e. not all the signal picked up by near end of microphone 1 is sent to far end. A part of the signal will be reflected back, become a line echo and will be spread out from near end of the speaker 10.

According to an embodiment of the present invention, the echo cancellation device further comprises a line resistor R_{line} 9, configured to equal to the impedance of the far end terminal device in audio line. Such kind of the line resistor R_{line} 9 can be a real resistor or an equivalent simulated resistance of the audio impedance of other equipments except that of the near end equipment of the system.

In Fig.2, the line resistance R_{line} 9 represents the impedance of the far end terminal device. As mentioned above, the line resistance R_{line} 9 changes because of the changes of the number of equipments accessing to the system and power consumption thereof; when the change exceeds the dynamic range permitted by the LEC 4 operation, LEC 4 will not work normally. Hence, some compensation shall be done to offset the changes of R_{line} 9 in such system.

Fig.3 illustrates a circuit diagram of the system current detection circuit according to an embodiment of the present invention.

Generally, the working mechanism of ALIC unit is that the impedance of an artificial inductor in power supply depends on its output current. ALIC detects the power supply output current, and converts it into the corresponding impedance variation so as to control the system impedance compensation

circuit to compensate line resistance R_{line} 9, which can be used to control the total resistance dynamically in a permissible range.

As shown in Fig.3, the system current detection circuit 18 further comprises: a power supply 20, a power load RL 21, a sampling resister $R_{sampling}$ 22 and a control unit 23, for example, a MCU. The MCU is configured to detect the system current and convert it into the impedance of audio by using a sampling resister $R_{sampling}$, and then control the switch of the compensation resistor network.

According to another aspect of the present invention, it provides an echo cancellation method for a 2-wire intercom system. The method is implemented by any one of said echo cancellation devices mentioned above.

Compared with the existing prior arts, the proposed solution of the present invention uses AEC to eliminate the acoustic echo which is caused by feedback sound from near end speaker reflection into near end microphone. Furthermore, through the LEC technology, the line echo caused by impedance mismatch of line-side tone cancellation circuit can be eliminated. Therefore, the system supports a high-quality full-duplex intercom and allows a small distance between the microphone and speaker, which will be beneficial to modularize the audio circuit and improve the assembly process for a better design with beautiful profile. By using ALIC technology, the proposed solution of the present invention does not need manually matching impedance according to the number of the equipments accessing to the system. Impedance matching and real-time compensation can be automatically achieved by the system, which can improve speech quality and system reliability, simplify system installation and debugging, and also reduce the installation time.

Though the present invention has been described on the basis of some preferred embodiments, those skilled in the art should appreciate that those embodiments should by no means limit the scope of the present invention. Without departing from the spirit and concept of the present invention, any variations and modifications to the embodiments should be within the apprehension of those with ordinary knowledge and skills in the art, and therefore fall in the scope of the present invention which is defined by the accompanied claims.

CLAIMS

1. An echo cancellation device for a 2-wire intercom system, wherein said echo cancellation device comprises an echo cancellation circuit (11), configured to eliminate the acoustic echo caused by the feedback of the audio signal reflected from the local speaker into local microphone and the line echo caused by the impedance mismatch of the line-side tone cancellation circuit.

2. The echo cancellation device according to claim 1, wherein said echo cancellation device further comprises a sidetone cancellation circuit (16), configured to eliminate sidetone echo caused by the mismatch of the line impedance R_{line} (9).

3. The echo cancellation device according to claim 2, wherein said line impedance further comprises the audio impedance of the far end device, other standby devices connected to the 2-wire system bus and the audio impedance of system power supply.

4. The echo cancellation device according to claim 1, wherein said echo cancellation device further comprises an automatic line impedance compensation circuit (17), configured to eliminate the line echo caused by the line impedance mismatch when the quantity of terminal devices changes.

5. The echo cancellation device according to claim 1, wherein said Echo cancellation circuit (11) further comprises:

a microphone amplifier (2), an acoustic echo canceller (3), a line echo canceller (4) and a line output amplifier (5) connected in sequence between a local microphone (1) and a sidetone cancellation circuit (16); and

at least a line output amplifier (13, 14) and a speaker amplifier (12) connected in sequence between said sidetone cancellation circuit (16) and a local speaker (10).

6. The echo cancellation device according to claim 5, wherein the outputs of said at least a line output amplifier (13, 14) are input to said acoustic echo canceller (3) and said line echo canceller (4) individually.

7. The echo cancellation device according to claim 1, wherein said sidetone cancellation circuit (16) further comprises: an operational amplifier (15), a line driver amplifier (6) and an audio source terminal resistor (7) connected in sequence between said echo cancellation circuit (11) and an automatic line impedance compensation circuit.

8. The echo cancellation device according to claim 2, wherein said automatic line impedance compensation circuit (17) further comprises: a compensation resistor network (8), a system current detection circuit (18) and a compensation switch (19).

9. The echo cancellation device according to claim 8, wherein said system current detection circuit (18) further comprises: a power supply (20), a power load RL (21), a sampling resister $R_{sampling}$ (22) and a control unit MCU (23); in which said RL is the whole load of all devices connected to the system.

10. The echo cancellation device according to claim 9, wherein said MCU is configured to detect the system current and convert it into the impedance of audio by using a sampling resister $R_{sampling}$, and then control the switch of the compensation resistor network.

11. The echo cancellation device according to claim 1, wherein said echo cancellation device further comprises a line resistor (9), configured to equal to the impedance of the far end terminal device in audio line.

12. An echo cancellation method for a 2-wire intercom system, wherein said method is implemented by any one of said echo cancellation devices of above claims.

DRAWING

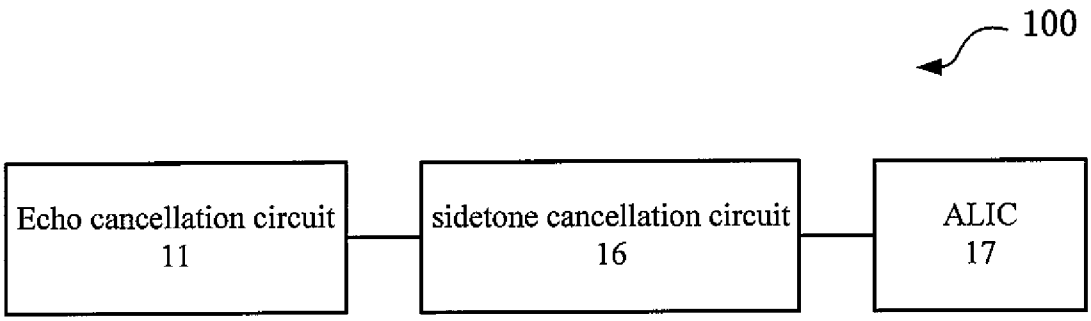


Fig.1

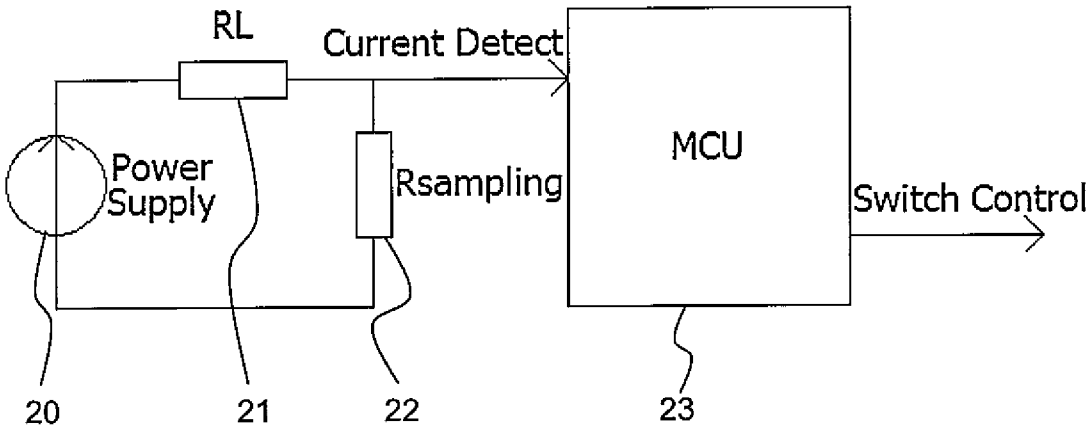


Fig.3

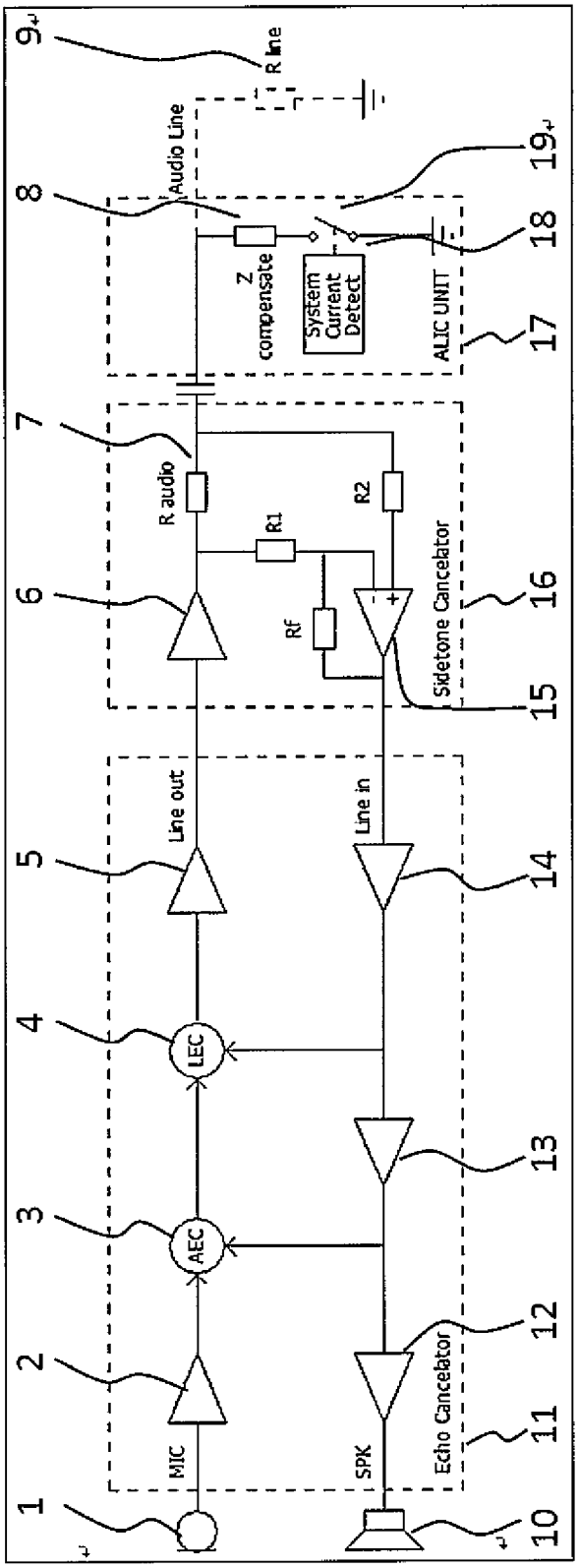

9
R line
Audio Line
8
19
18
Z compensate
System Current Detect
ALIC UNIT
17
7
R audio
R1
R2
6
Rf
Sidetone Cancelator
16
15
Line out
Line in
5
14
4
LEC
13
3
AEC
2
12
Echo Cancelator
11
MIC
SPK
1
10

Fig.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/074905

A. CLASSIFICATION OF SUBJECT MATTER

H04R 3/02 (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: H04R 3/-

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)

CNABS;CNTXT;CNKI;VEN: echo, speaker, microphone, impedance, mismatch, match, feedback, feed back, side tone, sidetone, acoustic echo, line echo, aec, lec

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO2004025937A1(PLANTRONICS INC.) 25 Mar.2004 (25.03.2004) description: page 7 line 24- page 10 line 26, claims 11-19, Fig.6	1-3
Y	CN101227761A (FORTEMEDIA INC.) 23 Jul.2008 (23.07.2008) description: page 4 lines 1-31, Fig.3	1-3
A	CN102271197A(APPLE INC.) 07 Dec.2011 (07.12.2011) the whole document	1-12
A	JP2009253404A(Brother Kogyo K.K.) 29 Oct.2009 (29.10.2009) the whole document	1-12

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 Jan.2013 (14.01.2013)	**31 Jan. 2013 (31.01.2013)**
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 ZHAO,Xiaoqing Telephone No. (86-10)62411426

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/074905

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