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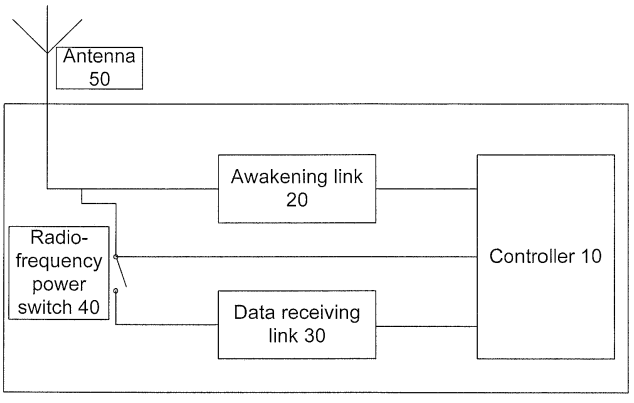
(54) ELECTRONIC TOLL COLLECTION SYSTEM, ON-BOARD UNIT AND DATA COMMUNICATION METHOD FOR ON-BOARD UNIT

(57) An Electronic Toll Collection (ETC) system, an On-Board Unit (OBU) and a data communication method of the OBU are provided. An OBU receives an awakening frequency signal, and matches an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU; when the response frequency preset by the OBU is matched with the awakening frequency of the awakening frequency signal, the OBU establishes data communication with a RSU. Only when the awakening frequency of the received awakening frequency signal is matched with the preset response frequency, the OBU establishes the data communication with the RSU; therefore, other communication data signals and the awakening frequency signals which do not meet requirements can not trigger the OBU to establish the data communication with the RSU. Error awakening rate of the OBU is greatly reduced, unnecessary power consumption is reduced and service life of the OBU is prolonged.

Fig. 1



EP 2 503 710 A1

Description

Technical Field

[0001] The present disclosure relates to the field of short range communications, in particular to an Electronic Toll Collection (ETC) system, an On-Board Unit (OBU) and a data communication method of the OBU.

Background

[0002] With the development of short range communication technology, an ETC system is used more and more widely in order to improve efficiency of expressway toll operations.

[0003] The national standard of ETC belongs to device specifications in networking charge technology standards of the Ministry of Communications and is a technology standard applied to the expressway toll collection for implementing the ETC. The national standard mainly prescribes two device specifications for OBU and Road Side Unit (RSU) respectively, and prescribes a Dedicated Short Range Communication (DSRC) protocol. The RSU is arranged at a toll lane. The OBU is installed inside a vehicle, and applies a double-chip label solution of IC card plus controller (i.e., CPU). The IC card is configured to store account number, account balance, transaction record, exit/entrance number, etc. The controller is configured to store information such as vehicle physical parameters including car owner and car type, and to guarantee communications between the OBU and the RSU.

[0004] The RSU and the OBU in the existing ETC system are provided with antenna oscillators. The OBU can communicate with the RSU initiatively, modulate and receive frequency signals transmitted by the RSU. In this condition, the OBU should be equipped with batteries. How to reduce power consumption of the OBU without affecting communication service capability between the OBU and the RSU is always a research focus in this technical field.

Summary

[0005] Examples of the present disclosure provides an ETC system, an OBU and a data communication method of the OBU, which realize lower power consumption and longer service life.

[0006] In an example, a data communication method of an OBU includes: an OBU receives an awakening frequency signal; the OBU matches an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU; when the response frequency of the OBU is matched with the awakening frequency of the awakening frequency signal, the OBU establishes data communication with an RSU.

[0007] In order to reduce power consumption, a controller of the OBU may adopt a low main frequency when performing the matching.

[0008] For the convenience of calculation of a period of the awakening frequency signal, a clock source of a timer in the controller may have a frequency which is the same as the low main frequency of the controller when matching, wherein the timer may be configured to calculate a square-wave period of the awakening frequency signal.

[0009] In order to further reduce power consumption, the controller may be in a low power consumption mode during non-transaction, the controller may adopt the low main frequency when performing the matching and adopt the high main frequency when the data communication with the RSU for transaction is established. Thus, power consumption in the whole operation may be further reduced.

[0010] In the implementation of the disclosure, the response frequency may have a range from 12 KHz to 16 KHz. The process of matching may be: the controller of the OBU may detect and calculate the square-wave period of the awakening frequency signal, when the calculated square-wave period of the awakening frequency signal is in the range of the square-wave period of the preset response frequency, the matching is successful.

[0011] In another example, an OBU is provided. The OBU is connected with an RSU, and the OBU includes a signal receiving unit configured to receive an awakening frequency signal; a data receiving link configured to establish data communication with the RSU; and a controller connected with the signal receiving unit and the data receiving link respectively, configured to match an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU, and configured to control the data receiving link to establish data communication with the RSU when the response frequency is matched with the awakening frequency of the awakening frequency signal.

[0012] The circuit layout of the OBU may be as follows: a radio-frequency power switch may be connected between the controller and the data receiving link; the controller may be further configured to: control the radio-frequency power switch to be turned on when the response frequency is matched with the awakening frequency of the awakening frequency signal, and control the radio-frequency power switch to be turned off when the response frequency is not matched with the awakening frequency of the awakening frequency signal.

[0013] Preferably, the controller may be in a low power consumption mode during non-transaction; the controller may adopt the low main frequency when matching is performed and adopt the high main frequency when the data communication with the RSU for transaction is established.

[0014] Preferably, when the controller performs the matching, a clock source of a timer in the controller may have a frequency which is the same as the main frequency of the controller, wherein the timer may be configured to calculate the square-wave period of the awakening frequency signal.

[0015] Preferably, the response frequency may have a range from 12 KHz to 16 KHz; the controller may be further configured to: detect at least two square-wave periods of the awakening frequency signal and calculate the square-wave period of the awakening frequency signal; when the calculated square-wave period of the awakening frequency signal is in the range of the square-wave period of the preset response frequency, the matching is successful.

[0016] In yet another example, an ETC system is provided, which can reduce power consumption. The ETC system includes an OBU and an RSU; the OBU establishes data communication with the RSU when the awakening frequency of the received awakening frequency signal is matched with the preset response frequency.

[0017] Compared with the prior art, the examples of the present disclosure may have the following advantages: 1) the premise of the data communication method of the OBU is that the controller of the OBU strictly limits the response frequency; only when the awakening frequency of the received awakening frequency signal is matched with the preset response frequency, can the controller of the OBU establish the data communication with the RSU; therefore, other communication data signals and awakening frequency signals which do not meet requirements can not trigger the controller to establish data communication with the RSU, and thus error awakening rate of the OBU is greatly reduced, and unnecessary power consumption is reduced and service life of the OBU is prolonged; 2) in the data communication method of the OBU, the controller adopts low main frequency such as 1 MHz when performing the matching, wherein the clock source of the timer has a frequency which is the same as the 1 MHz low main frequency of the controller; therefore, the controller also operates in the low main frequency so as to further reduce the power consumption of the controller when performing the matching; 3) in the data communication method of the OBU, the controller is in a low power consumption mode during non-transaction; when a data communication transaction with the RSU is established, the controller adopts a normal operating higher main frequency such as 16MHz, so as to further reduce power consumption in the whole operation of the OBU; 4) in the data communication method of the OBU, when the controller performs the matching, the clock source of the timer has a frequency which is the same as the low main frequency of the controller, thus, on one hand, power consumption is reduced, on the other hand, the square-wave period of the received frequency signal is conveniently calculated and determined; 5) in the data communication method of the OBU of the disclosure, the controller detects at least two square-wave periods of the awakening frequency signal, so as to accurately calculate the detected square-wave period of the awakening frequency signal.

Brief Description of the Drawings

[0018]

Fig. 1 shows a block diagram of hardware of an OBU according to an example of the present disclosure; and

Fig. 2 shows a flowchart of a process of error awakening and matching at an OBU according to an example of the present disclosure.

Detailed Description

[0019] The disclosure will be further illustrated below in detail in specific examples with reference to accompanying drawings.

[0020] Through research, the main power consumption during practical applications of the OBU does not occur in normal transaction, but in the error awakening of the OBU, as well as in the discharging process of the battery under various conditions and the like. The error awakening is one of main causes of the power consumption of the battery.

[0021] According to the national standard, the OBU is in a passive receiving mode, and it is thus required that the OBU can be awakened at multiple frequency points designated by the national standard. After being awakened, the OBU sets a response frequency point according to data received from the RSU so as to communicate with the RSU. Because the awakening of the OBU is broadband awakening, theoretically, error awakening of the OBU is caused probably in places with stronger radio communication signals.

[0022] In laboratory tests, through continuously adjusting signal strength of signals transmitted from a signal source, it is detected that the OBU can be awakened around frequency points of 900MHz, 800MHz and 2.4GHz, and it is easier to awake the OBU by mistake at a frequency point around 5GHz. As can be seen, for the OBU with broadband receiving, the error awakening is common in long-term usage. Therefore, the service life of the OBU can be prolonged by reduction of the OBU's power consumption caused by error awakening.

[0023] The ETC system for reducing error awakening in an example of the disclosure includes: an OBU and an RSU. The OBU includes a signal receiving unit, a controller 10 and a data receiving link 30. In this example, the signal receiving unit is an antenna 50, and is configured to receive an awakening frequency signal; the data receiving link 30 is controlled by the controller 10 to start data communication with the RSU after the OBU is awakened; the controller 10 has a preset response frequency, connected with the signal receiving unit and the data receiving link 30 respectively, and is configured to determine whether the awakening frequency of the awakening frequency signal is matched with the preset response frequency of the OBU, and to control the data receiving

link 30 to establish data communication with the RSU when the response frequency is matched with the awakening frequency.

[0024] Refer to Fig. 1, the OBU in this example of the disclosure includes an IC chip (not shown), a controller 10 and an antenna 50 functioning as a signal receiving unit. The controller 10 of the OBU presets response frequency. Circuit layout of the OBU is as follows: the controller 10 is connected with an awakening link 20 and is also connected with the data receiving link 30, and the data receiving link 30 is connected with a radio-frequency power switch 40 controlled by the controller 10. When determining that the awakening frequency signal is a modulation signal of 14KHz square wave, that is, the awakening frequency is matched with the preset response frequency, the controller 10 controls the radio-frequency power switch 40 to be turned on; otherwise, the controller 10 controls the radio-frequency power switch 40 to be turned off. In detail, when determining that the received awakening frequency signal is matched with the modulation signal of 14KHz square wave required by the national standard, the controller 10 controls the radio-frequency power switch 40 to be turned on to enable the OBU to establish data communication with the RSU.

[0025] In this example, the response frequency ranges from 12KHz to 16KHz.

[0026] In this example, when a vehicle with an OBU is far away from a toll station equipped with an RSU, the OBU is in a low power consumption mode. When the vehicle approaches the toll station, the vehicle runs over an induction line configured to start the RSU to transmit an awakening frequency signal and a data signal. The RSU transmits the awakening frequency signal and the data signal, and the OBU first detects the awakening frequency signal and checks whether it is a matched signal.

[0027] According to the national ETC technical requirement, the OBU can be awakened by a modulation signal of 14KHz square wave, and also can be awakened by a modulated data signal of radio communication. In order to meet the modulation requirement of the received awakening frequency signal for the OBU, the modulation signal of 14KHz square wave should be of 15 to 17 square-wave periods.

[0028] If it is strictly configured that the OBU can only be awakened by a 14KHz modulated square-wave awakening frequency signal, and if power is reduced as much as possible when matching a 14KHz modulated awakening frequency signal, reduction of the power consumption caused by error awakening can be realized.

[0029] When matching the awakening frequency signal, the controller 10 adopts low main frequency such as 1 MHz. When matching the awakening frequency signal, a clock source of a timer in the controller 10 has a frequency which is the same as 1 MHz low main frequency of the controller 10, and in this way, it is easier to calculate the awakening square-wave periods. Therefore, the controller 10 also operates in low main frequency to further reduce the power consumption of the controller during the matching. In addition, the clock source of the timer of the controller has a frequency which is the same as the low main frequency of the controller 10, and thus, on one hand, power consumption is reduced; on the other hand, the square-wave periods of the received frequency signal can be calculated and determined conveniently.

[0030] In order to achieve the reduction of error awakening rate and that of power consumption, it should be guaranteed in hardware design that the 14KHz awakening frequency signal can be received by the controller (single-chip microcomputer). In this example, the controller is a single-chip microcomputer which can switch between the low power consumption mode and the normal mode. The awakening frequency signals received by the controller should reach a certain number so that the controller has enough time to perform modulating, matching and processing. In this example, the circuit design of the OBU is: the awakening link and the data receiving link are designed separately and are connected to the controller respectively. The awakening response of the controller should be quick enough so as to receive the awakening frequency signal in time. When the controller performs matching for the awakening frequency signal in the example, no other elements are needed except the controller, and thus the power consumption is reduced.

[0031] Based on the hardware design of the OBU above, the awakening power consumption of the OBU mainly depends on the power consumption of the process of awakening and matching. When determining whether it is the 14KHz awakening frequency signal by using the single-chip microcomputer through software, the power consumption of the single-chip microcomputer is the total power consumption of the OBU during the awakening process. In the example, the total power consumption during the awakening process includes the power consumption of the awakening link and the power consumption of the single-chip microcomputer, i.e., the controller. The power consumption of the awakening link is very low and thus may be ignored. Generally, the power consumption of the single-chip microcomputer is in proportion to the operating main frequency. Therefore, the power consumption can be reduced if the single-chip microcomputer operates at an extremely low frequency matched with the 14KHz awakening frequency signal.

[0032] Through experiments, when the controller 10 operates at 1 MHz main frequency, the 1 MHz main frequency can handle the matching for the 14KHz awakening frequency signal. Generally, the power consumption of the controller 10 working at 1 MHz main frequency is about hundreds of microamperes, wherein the power consumption is relatively low and can greatly reduce the power consumption of the battery during error awakening. In order to match with the 14KHz awakening frequency signal, a lower main frequency may also be selected; however, the awakening and matching operations should not affect the practical transaction, that is, the transaction

range can not be limited and the original transaction range should be kept unchanged even though the awakening and matching operations are added. In addition, due to fluctuation of a radio signal when the radio signal is received, the matching range can not be limited too strictly. Moreover, if the main frequency is too low, the matching would be too strict. Therefore, it is proved through experiments that 1 MHz main frequency is quite appropriate.

[0033] In the example, the controller 10 is in the low power consumption mode during non-transaction time (that is, when the OBU does not approach the RSU, the OBU is in a sleep state). The controller 10 adopts higher main frequency for normal operating, such as 16MHz, during data communication transaction with the RSU, so as to further reduce the power consumption in the whole operating of the OBU.

[0034] The data communication method of the OBU in the present disclosure substantially includes the following steps:

the controller of the OBU presets response frequency; and

the controller of the OBU establishes data communication with the RSU when the awakening frequency of the received awakening frequency signal is matched with the preset response frequency.

[0035] In the data communication method of the OBU in the example, the controller 10 of the OBU strictly limits the response frequency; only when the awakening frequency of the received awakening frequency signal is matched with the preset response frequency, can the controller 10 of the OBU establish the data communication with the RSU. Therefore, other communication data signals and the awakening frequency signals which do not satisfy requirements can not trigger the controller to establish data communication with the RSU, and thus the error awakening rate of the OBU is greatly reduced and unnecessary power consumption is reduced.

[0036] The process of matching with the 14KHz awakening frequency signal is: calculating the square-wave period of the awakening frequency signal by counting the clock width of the square-wave period of the awakening frequency signal. When the awakening frequency signal is matched with the response frequency, no matter which hop the period is calculated from, the period should be the square-wave period of 14KHz awakening frequency signal since there is no phase difference in a square wave, and thus the matching is relatively simple.

[0037] Key points for implementing the matching are as follows:

1) Matching precision of the 14KHz awakening frequency signal: in order to have more accurate matching, the time recorded by the timer after matching with two complete square-wave periods is obtained, the time is divided by 2 and the division result is taken as the square-wave period of the detected awakening frequency signal. If the time meets the time condition of two square-wave periods of the 14KHz awakening frequency signal, that is, if the square-wave period of the awakening frequency signal calculated and obtained by the timer is around 73 microseconds, it is considered that the matching is successful. In the example, when the calculated and obtained square-wave period of the awakening frequency signal ranges from 63 microseconds to 83 microseconds, it is considered that the matching is successful.

2) If the number of hops reaches four, it is indicated that two continuous square-wave periods are detected.

3) After the OBU receives the awakening frequency signal, the controller 10 starts to match the received awakening frequency signal with the preset response frequency. Because the signal is subjected to air transmission and radio-frequency link modulation, and the preciseness of other elements and the like, the obtained awakening square-wave frequency has some errors. Therefore, in this example, it is considered that the matching is successful when the preset response frequency is around 12-16KHz.

4) When the period of the received 14KHz awakening square-wave is matched, the controller 10 is firstly configured to work in a low main frequency (1 MHz in the example). In this way, the power consumption of the controller is saved as much as possible. In practical application, the main frequency can be set according to complexity of software algorithm, so as to avoid affecting the awakening sensitivity of the OBU, and so that the operation of the OBU would not be affected by introducing this function. Then, the clock source of the timer is set. The clock source of the timer is the running clock 1 MHz of the controller, i.e., the same as the main frequency of the controller. The square-wave matching of the awakening frequency signal is then started.

5) Setting timeout in the matching process: since the square-wave period which is matched with the 14KHz standard awakening frequency signal is about 73 microseconds, the timeout may be set as hundreds of microseconds.

[0038] Refer to Fig. 2, the matching process at the OBU is as follows:

the signal receiving unit of the OBU, such as antenna 50, receives an awakening frequency signal and transmits the awakening frequency signal to the controller 10 through the awakening link 20.

Step 201: After receiving the awakening frequency signal, the controller 10 is awakened and then operates in an active state. At this moment, only the controller 10 is in a power-on state, other circuits are still kept in a power off state. The controller 10 is set to operate in the low main frequency operating mode (1 MHz in this example). Further, a timer is configured in the controller and the clock source of the timer has a frequency which is the same as the main frequency of the controller.

Step 202: Repeatedly detect whether the electrical level of the signal pin connected between the controller 10 and the awakening link 20 has a hop; if yes, start to count the number of hops; otherwise, determine whether it is timeout. If it is timeout, the matching process is terminated, that is, Step 207 is performed; otherwise, Step 202 is performed again. Because the square-wave time matched with the 14KHz standard awakening signal is about 73 microseconds, the timeout period is set as hundreds of microseconds.

Specifically, if a hop is detected, Step 203 is performed; if no hop is detected during a preset period of time (200 microseconds in this example), it is indicated that it is an error awakening, and then Step 207 is performed.

Step 203 to Step 204: If there is a hop, it is determined whether it is the first hop. If it is the first hop, the timer is cleared when the first hop is detected, and after the timer is cleared, the timer starts timing and the controller starts to record the number of hops. Here, the first hop would not be recorded in the number of hops. If it is not the first hop, the number of hops is recorded, that is, the current number of hops is increased by 1.

Step 205: It is determined whether the number of hops reaches 4, if yes, go to Step 206; otherwise, return to Step 202. The number of hops reaching 4 indicates that the timer has recorded two square-wave periods of the awakening frequency signal.

Step 206: It is determined whether two continuous square-wave periods of the awakening frequency signal are matched with the square-wave period of the 14KHz response frequency, if yes, it is indicated that the received awakening square-wave is the correct awakening square-wave, then go to Step 207; otherwise, it is indicated that the matching process fails, then go to Step 208.

Step 207: The controller 10 is set to work in the frequency of the normal operating mode (16MHz in the example). The input/output state and the initial output electrical level of each pin are also set. The clock source of the timer is also set and starts to work after it is set. The power supply of the radio-frequency link is turned on through the radio-frequency power switch 40. After those settings, the ODU starts working normally.

Step 208: It is determined that the OBU is awakened by mistake. In order to save power consumption, the controller 10 is immediately set as entering a sleep state, and then works in a low power consumption mode.

[0039] At least the following two advantages can be achieved through the above examples.

[0040] On one hand, in the hardware circuit design, the data receiving link and the awakening link of the OBU are set respectively. And it is thus possible for software to realize the matching for the 14KHz awakening frequency signal in the case that only the awakening link works. In this way, power consumption can be reduced. Because the data receiving link has higher performance and should be power on to operate, the power consumption caused by error awakening can be completely avoided in the way that the data receiving is started only after correct awakening.

[0041] On the other hand, during the matching for the 14KHz awakening frequency signal, a low main frequency (1MHz in this example) is used, and thus the power consumption of the OBU is further reduced.

[0042] The foregoing is only the preferred examples of the present disclosure and is not intended to limit the scope of the present invention. Any modification, equivalent substitution, or improvement made without departing from principle of the present invention should be covered by the scope set forth in the appended claims.

Claims

1. A data communication method of an On-Board Unit (OBU), comprising:

   receiving, by the OBU, an awakening frequency signal;
   matching, by the OBU, an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU; and
   establishing, by the OBU, data communication with a Road Side Unit (RSU) when the response frequency preset by the OBU is matched with the awakening frequency of the awakening frequency signal.

2. The data communication method of the OBU according to claim 1, wherein the OBU comprises a controller; the controller operates in a low power consumption mode during non-transaction, the controller operates in a low main frequency when perform-

ing the matching, and the controller operates in a high main frequency when the data communication with the RSU for transaction is established.

3. The data communication method of the OBU according to claim 2, wherein a clock source of a timer in the controller has a frequency which is the same as the main frequency of the controller when the controller performs the matching, wherein the timer is configured to calculate a square-wave period of the awakening frequency signal.

4. The data communication method of the OBU according to claim 3, wherein a range of the response frequency is 12 KHz to 16 KHz; and wherein the matching comprises: detecting and calculating the square-wave period of the awakening frequency signal by the controller of the OBU, and determining that the matching is successful when the calculated square-wave period of the awakening frequency signal is in the range of a square-wave period of the response frequency.

5. An On-Board Unit (OBU) connected with a Road Side Unit (RSU), comprising: a signal receiving unit, a data receiving link and a controller; wherein
the signal receiving unit is configured to receive an awakening frequency signal;
the data receiving link is configured to establish data communication with the RSU;
the controller is connected with the signal receiving unit and the data receiving link respectively, and is configured to match an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU, and to control the data receiving link to establish the data communication with the RSU when the response frequency is matched with the awakening frequency of the awakening frequency signal.

6. The OBU according to claim 5, wherein a radio-frequency power switch is connected between the controller and the data receiving link;
the controller is further configured to: control the radio-frequency power switch to be turned on when the response frequency is matched with the awakening frequency of the awakening frequency signal, and control the radio-frequency power switch to be turned off when the response frequency is not matched with the awakening frequency of the awakening frequency signal.

7. The OBU according to claim 5 or 6, wherein the controller is in a low power consumption mode during non-transaction; the controller is in a low main frequency when matching is performed, and the controller is in a high main frequency when the data communication with the RSU for transaction is established.

8. The OBU according to claim 7, wherein a clock source of a timer in the controller has a frequency which is the same as the main frequency of the controller when the controller performs the matching, wherein the timer is configured to calculate a square-wave period of the awakening frequency signal.

9. The OBU according to claim 8, wherein a range of the response frequency is 12 KHz to 16 KHz; and wherein the controller is further configured to: detect at least two square-wave periods of the awakening frequency signal and calculate the square-wave period of the awakening frequency signal, and determine that the matching is successful when the calculated square-wave period of the awakening frequency signal is in the range of a square-wave period of the response frequency.

10. An Electronic Toll Collection (ETC) system, comprising an On-Board Unit (OBU) and a Road Side Unit (RSU);
wherein the OBU comprises: a signal receiving unit, a data receiving link and a controller;
the signal receiving unit is configured to receive an awakening frequency signal;
the data receiving link is configured to establish data communication with the RSU;
the controller is connected with the signal receiving unit and the data receiving link respectively, and is configured to match an awakening frequency of the awakening frequency signal with a response frequency preset by the OBU, and to control the data receiving link to establish the data communication with the RSU when the response frequency is matched with the awakening frequency of the awakening frequency signal.

11. The ETC system according to claim 10, wherein a radio-frequency power switch is connected between the controller and the data receiving link; the controller is further configured to: control the radio-frequency power switch to be turned on when the response frequency is matched with the awakening frequency of the awakening frequency signal, and control the radio-frequency power switch to be turned off when the response frequency is not matched with the awakening frequency of the awakening frequency signal.

12. The ETC system according to claim 10 or 11, wherein the controller is in a low power consumption mode during non-transaction; the controller is in a low main frequency when matching is performed, and the controller is in a high main frequency when the data communication with the RSU for transaction is established.

13. The ETC system according to claim 12, wherein a clock source of a timer in the controller has a frequency which is the same as the main frequency of the controller when the controller performs the matching, wherein the timer is configured to calculate a square-wave period of the awakening frequency signal.

14. The ETC system according to claim 13, wherein a range of the response frequency is 12 KHz to 16 KHz; the controller is further configured to: detect at least two square-wave periods of the awakening frequency signal and calculate the square-wave period of the awakening frequency signal, and determining that the matching is successful when the calculated square-wave period of the awakening frequency signal is in the range of a square-wave period of the response frequency.

Fig. 1

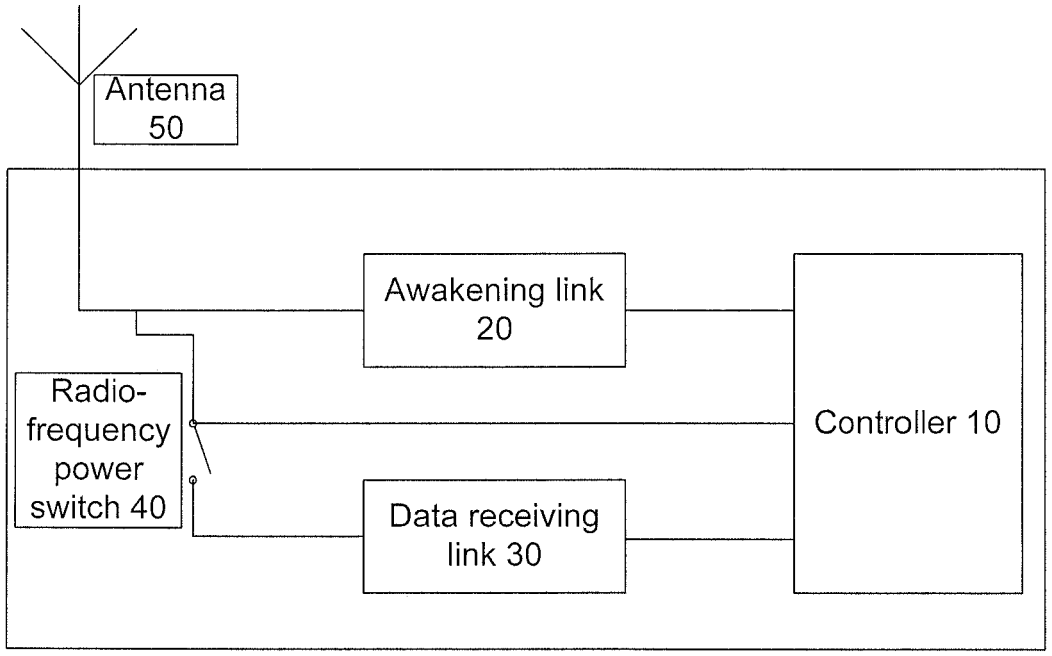
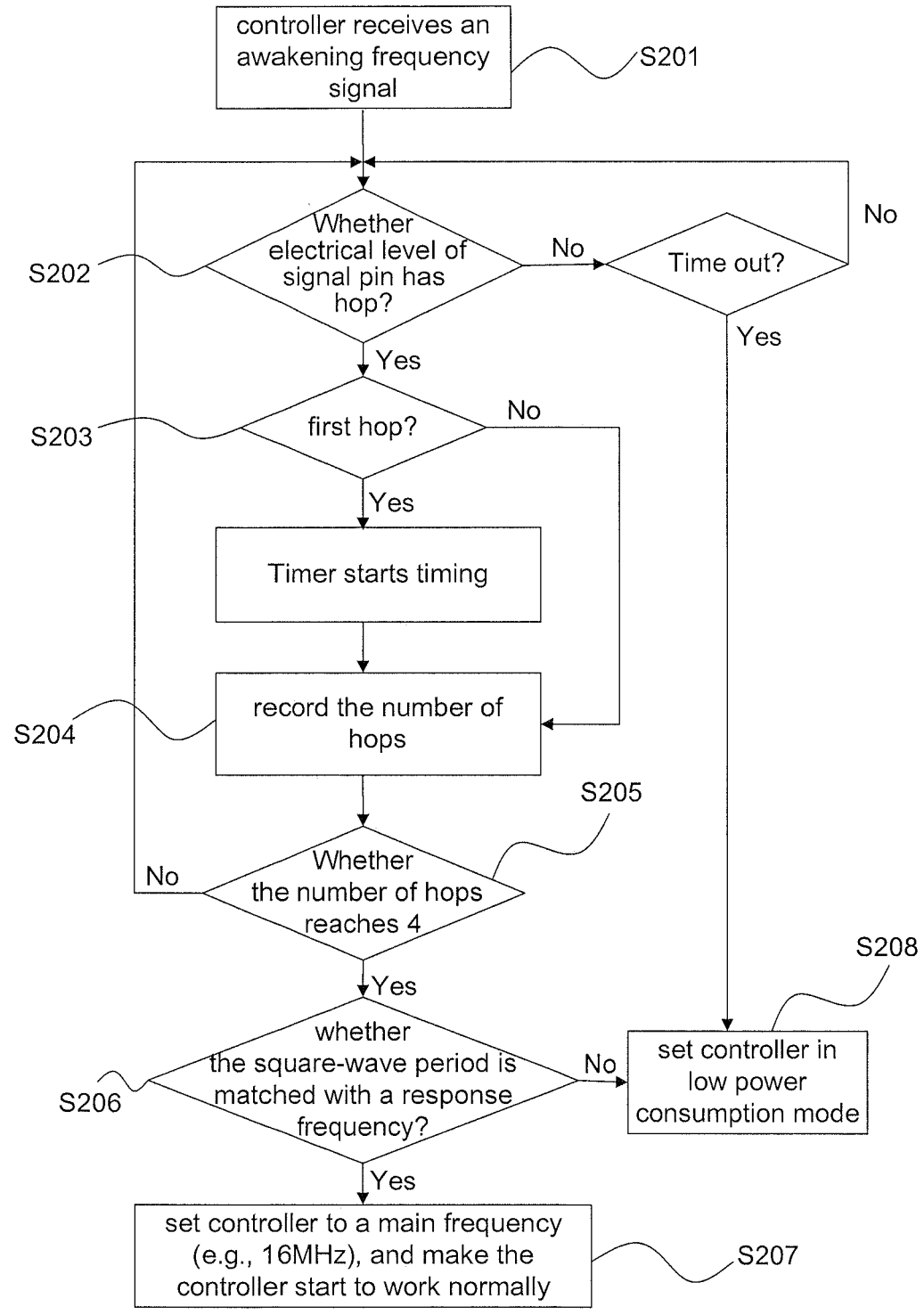

Antenna
50
Awakening link
20
Radio-
frequency
power
switch 40
Controller 10
Data receiving
link 30

Fig. 2


controller receives an awakening frequency signal
S201
Whether electrical level of signal pin has hop?
S202
No
Time out?
No
Yes
Yes
first hop?
S203
No
Yes
Timer starts timing
record the number of hops
S204
S205
Whether the number of hops reaches 4
No
Yes
S208
whether the square-wave period is matched with a response frequency?
S206
No
set controller in low power consumption mode
Yes
set controller to a main frequency (e.g., 16MHz), and make the controller start to work normally
S207

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2010/074179

A. CLASSIFICATION OF SUBJECT MATTER

H04B7/26(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: H04B,G07B,G07F

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)

CPRS;CNKI;WPI;EPODOC: on board, vehicle, road, electronic, toll collection, charg+, non-stop, awaken+, rous+, respond+, enable, activate+, frequency, equal, same, sleep, match

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN101458830A(NIV NANJING SCIENCE & TECH) 17 Jun. 2009 (17.06.2009) description page 2 line 4 to page 4 line 1	1,2,5-7,10-12
X	CN1667653A(SHANGHAI HUAHONG INTEGRATED CIRCUIT CO L)14 Sep. 2005 (14.09.2005) abstract, claims 1-6	1,2,5-7,10-12
X	CN101256681A(YILONG APPLIED SOFTWARE DEV CO LTD SHANGHAI) 03 Sep.2008 (03.09.2008) description page 3 line 4 to page 8 line 21	1,2,5-7,10-12
A	CN101299280A(SHENZHEN JINYI SCI TECHNOLOGY CO LTD)05 Nov. 2008 (05.11.2008) the whole document	1-14
A	CN1214489A(SAMSUNG ELECTRONICS CO LTD)21 Apr.1999 (21.04.1999) the whole document	1-14

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

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"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01Sep. 2010 (01.09.2010)	**28 Oct. 2010 (28.10.2010)**
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 JIA, Jie Telephone No. (86-10)62411405

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2010/074179

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CN1667653A	14.09.2005	CN100568292C	09.12.2009
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