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- (71) **Applicants:** SHENZHEN BYD AUTO R&D COMPANY LIMITED [CN/CN]; Part B, 1/F, Bldg#B2, Yucan Industrial Area, Lanzhu Road, Shenzhen Export Processing Zone, Shenzhen Grand Industrial Zone, Shenzhen, Guangdong 518118 (CN). BYD COMPANY LIMITED [CN/CN]; No. 3009 BYD Road, Pingshan, Shenzhen, Guangdong 518118 (CN).
- (72) **Inventors:** WANG, Tiejun; No. 3009 BYD Road, Pingshan, Shenzhen, Guangdong 518118 (CN). LI, Chuanbo; No. 3009 BYD Road, Pingshan, Shenzhen, Guangdong

518118 (CN). LI, Qili; No. 3009 BYD Road, Pingshan, Shenzhen, Guangdong 518118 (CN).

- (74) **Agent:** TSINGYIHUA INTELLECTUAL PROPERTY LLC; Room 301, Trade Building, Zhaolanyuan, Tsinghua University, Qinghuayuan, Haidian District, Beijing 100084 (CN).

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- (54) **Title:** METHOD AND APPARATUS FOR CONTROLLING ELECTRONIC PARKING BRAKE SYSTEM

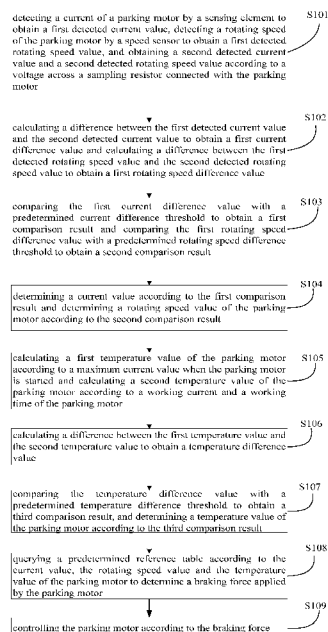


Fig. 3

- (57) **Abstract:** A method and an apparatus for controlling an electronic parking brake system are provided. The method includes: obtaining first and second detected current value by a sensing element and a sampling resistor respectively; obtaining first and second detected rotating speed values by a speed sensor and the sampling resistor respectively; comparing the first and second detected current values to obtain a first result, and comparing the first and second detected rotating speed values to obtain a second result; determining the current value and the rotating speed value according to the first and second results respectively; calculating a first and second temperature values; comparing the first and second temperature values to obtain a third result; determining the temperature value according to the third result; obtaining the braking force according to the current value, the rotating speed value and the temperature value; and controlling the parking motor according to the braking force.



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METHOD AND APPARATUS FOR CONTROLLING ELECTRONIC PARKING BRAKE SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

5 This application claims priority and benefits of Chinese Patent Application No. 201210590093.9, filed with State Intellectual Property Office, P. R. C. on December 29, 2012, the entire content of which is incorporated herein by reference.

FIELD

10 Embodiments of the present disclosure generally relate to a vehicle braking technology field, more particularly, to a method and an apparatus for controlling an electronic parking brake system.

BACKGROUND

A brake system is configured to decelerate a vehicle during driving until stopping the vehicle
15 and to keep the vehicle in a static state. The brake system includes a parking brake equipment.

An operation method for the parking brake equipment is that a driver operates a brake bar to drive a parking cable, and then the parking cable drives a brake connected with the cable to provide a braking force for the wheels, thus keeping the wheels in the static state. When the brake bar is released, the parking cable is loosened so as to release the braking force from the wheels.
20 This type of parking brake equipment which uses a pulling force of the parking cable to apply the braking force to the wheels or release the braking force from the wheels is referred to as a cable brake type of parking brake equipment.

The cable brake works only when the driver operates the brake bar, moreover, it functions only when the driver pulls up the brake bar with great force, which not only influences a usage of
25 the inner space of the vehicle, but also brings trouble to the driver, for example, a thin and weak driver may be unable to pull up the brake bar. Accordingly, an electronic parking brake system adopting a parking motor instead of the driver to pull up the brake bar has been proposed.

The electronic parking brake system includes an electronic control unit, a parking motor, a gear train, a screw, a threaded sleeve and a parking cable. The electronic control unit is
30 communicated with the controller area network of the vehicle to obtain an intention of the driver so as to achieve the driving brake and the parking brake, in which the parking brake is the common

function of the electronic parking brake system.

The brake process of the electronic parking brake system is described as follows.

When the electronic control unit receives a command and determines that the command is a valid command, the electronic control unit controls a relay to be turned on so as to electrify the parking motor, the parking motor generates a rotation after being electrified, and then the transfer gear train transmits the rotation to the threaded sleeve to drive the screw. Since the rotation of the screw is limited by the threaded sleeve, the screw moves along a straight line under the rotation of the threaded rod, so as to drive the parking cable to lengthen or shorten, in which the brake is tightened when the parking cable shortens, and the brake is released when the parking cable lengthens.

For the electronic control unit, the key is to determine a value of the cable force. When a sensor for detecting the cable force breaks down, it is hard to determine whether a required braking force is reached, thus causing a serious threat to the safety of the vehicle.

SUMMARY

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

For this, one objective of the present disclosure is to provide a method for controlling an electronic parking brake system, which can effectively detect a fault of the electronic parking brake equipment so as to ensure an operation security of the electronic parking brake equipment.

Another objective of the present disclosure is to provide an apparatus for controlling an electronic parking brake system, which can effectively detect the fault of the electronic parking brake equipment so as to ensure the operation security of the electronic parking brake equipment.

According to embodiments of a first aspect of the present disclosure, a method for controlling an electronic parking brake system is provided. The method includes: obtaining a first detected current value, a first detected rotating speed value, a second detected current value and a second detected rotating speed value of a parking motor; calculating a difference between the first detected current value and the second detected current value to obtain a first current difference value and calculating a difference between the first detected rotating speed value and the second detected rotating speed value to obtain a first rotating speed difference value; comparing the first current difference value with a predetermined current difference threshold to obtain a first

comparison result and comparing the first rotating speed difference value with a predetermined rotating speed difference threshold to obtain a second comparison result; determining a current value according to the first comparison result and determining a rotating speed value of the parking motor according to the second comparison result; calculating a first temperature value of the parking motor according to a maximum current value when the parking motor is started and calculating a second temperature value of the parking motor according to a working current and a working time of the parking motor; calculating a difference between the first temperature value and the second temperature value to obtain a temperature difference value; comparing the temperature difference value with a predetermined temperature difference threshold to obtain a third comparison result, and determining a temperature value of the parking motor according to the third comparison result; querying a predetermined reference table according to the current value, the rotating speed value and the temperature value of the parking motor to determine a braking force applied by the parking motor; and controlling the parking motor according to the braking force.

With the method for controlling an electronic parking brake system according to embodiments of the present disclosure, since both the current and the rotating speed of the parking motor are obtained, a dual protection for the current and the rotating speed is realized, thus increasing an accuracy of the braking force (this is because the braking force is estimated according to a combination of the current and the rotating speed). Furthermore, since no other element for measuring force is used, a mechanical structure of the electronic parking brake system is simplified and a manufacturing cost of the electronic parking brake system is reduced.

According to embodiments of a second aspect of the present disclosure, an apparatus for controlling an electronic parking brake system is provided. The electronic parking brake system comprises a parking motor, a sensing element for detecting a current of a parking motor to obtain a first detected current value, a speed sensor for detecting a rotating speed of the parking motor to obtain a first detected rotating speed value, and a sampling resistor connected with the parking motor. The apparatus comprises: a first obtaining module configured to read the first detected current value and the first detected rotating speed value and to obtain a second detected current value and a second detected rotating speed value according to a voltage across the sampling resistor; a first calculating module configured to calculate a difference between the first detected current value and the second detected current value to obtain a first current difference value, to

calculate a difference between the first detected rotating speed value and the second detected rotating speed value to obtain a first rotating speed difference value, to compare the first current difference value with a predetermined current difference threshold to obtain a first comparison result, to compare the first rotating speed difference value with a predetermined rotating speed difference threshold to obtain a second comparison result, to determine a current value of the parking motor according to the first comparison result, and to determine a rotating speed value of the parking motor according to the second comparison result; a second obtaining module configured to obtain a maximum current value when the parking motor is started, a working current and a working time of the parking motor, to calculate a first temperature value of the parking motor according to the maximum current value when the parking motor is started and to calculate a second temperature value of the parking motor according to the working current and the working time of the parking motor; a second calculating module configured to calculate a difference between the first temperature value and the second temperature value to obtain a temperature difference value, to compare the temperature difference value with a predetermined temperature difference threshold to obtain a third comparison result, and to determine a temperature value of the parking motor according to the third comparison result; a reference table storage module configured to store a reference table indicating corresponding relationships between currents, rotating speeds, temperatures and torques of the parking motor; a braking force calculating module configured to query the reference table according to the current value, the rotating speed value and the temperature value of the parking motor so as to determine the braking force applied by the parking motor; and a control module configured to control the parking motor according to the determined braking force.

With the apparatus for controlling the electronic parking brake system according to embodiments of the present disclosure, since the current of the parking motor is detected by the sensing element and the sampling resistor connected with the parking motor respectively, and the rotating speed of the parking motor is detected by the speed sensor and the sampling resistor connected with the parking motor respectively, a dual protection for the current and the rotating speed is obtained, thus increasing an accuracy of the braking force (this is because the braking force is estimated according to a combination of the current and the rotating speed). Furthermore, since no other element for measuring force is used, a mechanical structure of the electronic parking brake system is simplified and a manufacturing cost of the electronic parking brake system

is reduced.

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

5

BRIEF DESCRIPTION OF THE DRAWINGS

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

10 Fig. 1 is a schematic diagram of an electronic parking brake equipment according to an embodiment of the present disclosure;

Fig. 2 is a block diagram of an electronic control unit according to an embodiment of the present disclosure;

15 Fig. 3 is a flow chart of a method for controlling an electronic parking brake system according to an embodiment of the present disclosure; and

Fig. 4 is a flow chart of a method for controlling an electronic parking brake system according to another embodiment of the present disclosure.

DETAILED DESCRIPTION

20 Reference will be made in detail to embodiments of the present disclosure. Embodiments of the present disclosure will be shown in drawings, in which the same or similar elements and the elements having same or similar functions are denoted by like reference numerals throughout the descriptions. The embodiments described herein according to drawings are explanatory and illustrative, not construed to limit the present disclosure.

25 The following description provides a plurality of embodiments or examples configured to achieve different structures of the present disclosure. In order to simplify the present disclosure, components and dispositions of the particular embodiment are described in the following, which are only explanatory and not construed to limit the present disclosure. In addition, the present disclosure may repeat the reference number and/or letter in different embodiments for the purpose
30 of simplicity and clarity, and the repeat does not indicate the relationship of the plurality of embodiments and/or dispositions. Moreover, in description of the embodiments, the structure of

the second characteristic “above” the first characteristic may include an embodiment formed by the first and second characteristic contacted directly, and also may include another embodiment formed between the first and the second characteristic, in which the first characteristic and the second characteristic may not contact directly.

5 In the description of the present disclosure, unless specified or limited otherwise, it should be noted that, terms “mounted,” “connected” and “coupled” may be understood broadly, such as electronic connection or mechanical connection, inner communication between two elements, direct connection or indirect connection via intermediary. Those having ordinary skills in the art should understand the specific meanings in the present disclosure according to specific situations.

10 With reference to the following descriptions and drawings, these and other aspects of embodiments of the present disclosure will be distinct. In the descriptions and drawings, some particular embodiments are described in order to show means of the principles of embodiments according to the present disclosure, however, it should be appreciated that the scope of embodiments according to the present disclosure is not limited. On the contrary, embodiments of
15 the present disclosure include all the changes, alternatives, and modifications falling into the scope of the spirit and principles of the attached claims.

Fig. 1 is a schematic diagram of an electronic parking brake equipment according to an embodiment of the present disclosure. As shown in Fig. 1, the electronic parking brake equipment is a cable brake type of electronic parking brake equipment, and comprises a parking motor 10, a
20 gear train 20, a screw 25, a threaded sleeve 30 and a parking cable 40. The cable brake type of electronic parking brake equipment further comprises a speed sensor 110 for detecting a rotating speed of the parking motor 10 during an operation of the electronic parking brake equipment.

An electronic parking brake system comprises the above cable brake type of electronic parking brake equipment, a brake, wheels, a parking switch, an electronic control unit (ECU), a
25 sensing element, a sampling resistor and a display unit. The electronic parking brake system further comprises a battery for supplying power to each component. The sensing element is small in size and may be integrated in the circuit board without involving in the current loop of the parking motor 10. The sensing element is configured to detect a current of the parking motor 10. The sampling resistor is connected in the current loop of the parking motor 10 and advantageously
30 is a copper plate.

Under the operation of the parking switch, the ECU controls the parking motor 10 to rotate

forwardly or reversely with the power provided by the battery, and then the parking motor 10 drives the parking cable 40 to shorten or lengthen via the gear train 20, the screw 25 and the threaded sleeve 30, so as to apply a braking force to the brake or release a braking force from the brake.

5 The ECU estimates the braking force applied to the brake according to an estimated temperature of the parking motor 10, currents of the parking motor 10 detected by the sensing element and the sampling resistor respectively, and rotating speeds of the parking motor 10 detected by the speed sensor 110 and the sampling resistor respectively, and then controls a rotation of the parking motor 10 according to the estimated braking force, so as to control a tension
10 force of the cable and the braking force of the brake. By analyzing the currents and the rotating speeds detected by the sensing element, the speed sensor and the sampling resistor, the fault in the electronic parking brake equipment can be detected, and thus a corresponding warning can be generated, and a corresponding operation can be performed.

15 Fig. 2 is a schematic diagram of an electronic control unit according to an embodiment of the present disclosure.

As shown in Fig. 2, the ECU 100 comprises a first obtaining module 100a, a first calculating module 100b, a second obtaining module 100c, a second calculating module 100d, a reference table storage module 100e, a braking force calculating module 100f and a control module 100g.

20 The first obtaining module 100a is configured to read a first detected current value I1 of the sensing element and a first detected rotating speed value R1 of the speed sensor 110, and to obtain a second detected current value I2 and a second detected rotating speed value R2 according to a voltage across the sampling resistor. Specifically, the second detected current value I2 is calculated after amplifying the voltage across the sampling resistor by an amplifier. The second detected rotating speed value R2 is obtained as follows: firstly, a ripple voltage across the sampling resistor
25 is amplified with a larger amplification coefficient to obtain a number of commutations occurring in a commutator bar of the parking motor, and then the number of commutations is divided by a number of commutations per circle to obtain the second detected rotating speed value R2.

30 The second obtaining module 100c is configured to obtain a maximum current value when the parking motor is started, a working current and a working time of the parking motor, to calculate a first temperature value T1 of the parking motor according to the maximum current value when the parking motor is started and to calculate a second temperature value T2 of the

parking motor according to the working current and the working time of the parking motor. Specifically, a winding resistance of the parking motor 10 is firstly obtained by dividing the voltage (measurable) of the parking motor by the maximum current value, and then the first temperature value T1 can be obtained according to the winding resistance, since the winding resistance of the parking motor changes with the temperature. On the other hand, firstly, a total power of the parking motor is calculated according to the voltage, the working current, the working time and the time interval of the parking motor, and an output force is calculated according to the current value and the rotating speed value of the parking motor so as to determine a mechanical power of the parking motor, and then a heat energy generated by the parking motor is obtained by subtracting the mechanical power from the total power, finally, the second temperature value T2 of the parking motor 10 can be estimated by subtracting the heat dissipation during the time interval from the heat energy. The mechanical power may have a certain deviation, but the deviation only has a very little effect on the power difference value. When the current is used to calculate the output force of the parking motor, considering the influence of the temperature on the parking motor, an output torque of the parking motor corresponding to the current value may change slightly. Furthermore, when the torque is constant, the higher the temperature is, the greater the rotating speed change corresponding to a unit torque is. Thus, by detecting the temperature of the parking motor, the deviation of the output force of the parking motor can be corrected. When the temperature is too high or too low, in order to obtain a same braking force, certain corrected values of the current and the rotating speed are required.

The first calculating module 100b is configured to calculate a difference between the first detected current value I1 and the second detected current value I2 to obtain a first current difference value $\Delta I1$, to calculate a difference between the first detected rotating speed value R1 and the second detected rotating speed value R2 to obtain a first rotating speed difference value $\Delta R1$, to determine whether the first current difference value $\Delta I1$ is less than a predetermined current difference threshold ΔI and the first rotating speed difference value $\Delta R1$ is less than a predetermined rotating speed difference threshold ΔR .

Specifically, when the first current difference value $\Delta I1$ is less than or equal to the predetermined current difference threshold ΔI and the first rotating speed difference value $\Delta R1$ is less than or equal to the predetermined rotating speed difference threshold ΔR , everything is normal, then the first detected current value I1 may be determined as the current value and the first

detected rotating speed value R1 may be determined as the rotating speed value to calculate the braking force.

When the first current difference value $\Delta I1$ is not less than the predetermined current difference threshold ΔI but the first rotating speed difference value $\Delta R1$ is less than or equal to the predetermined rotating speed difference threshold ΔR , a single fault alarm is generated, and the first calculating module 100b queries a predetermined correlation table of currents and rotating speeds according to the first detected rotating speed value R1 or the second detected rotating speed value R2 to obtain a standard current value I3, calculates a difference between the first detected current value I1 and the standard current value I3 to obtain a second current difference value $\Delta I2$ and calculates a difference between the second detected current value I2 and the standard current value I3 to obtain a third current difference value $\Delta I3$. When the second current difference value $\Delta I2$ is less than or equal to the predetermined current difference threshold ΔI , the first calculating module 100b determines the first detected current value I1 as the current value. When the third current difference value $\Delta I3$ is less than or equal to the predetermined current difference threshold ΔI , the first calculating module 100b determines the second detected current value I2 as the current value.

Similarly, when the first current difference value $\Delta I1$ is less than or equal to the predetermined current difference threshold ΔI but the first rotating speed difference value $\Delta R1$ is not less than the predetermined rotating speed difference threshold ΔR , a single fault alarm is generated, and the first calculating module 100b queries the predetermined correlation table of currents and rotating speeds according to the first detected current value I1 or the second detected current value I2 to obtain a standard rotating speed value R3, calculates a difference between the first detected rotating speed value R1 and the standard rotating speed value R3 to obtain a second rotating speed difference value $\Delta R2$ and calculates a difference between the second detected rotating speed value R2 and the standard rotating speed value R3 to obtain a third rotating speed difference value $\Delta R3$. When the second rotating speed difference value $\Delta R2$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first calculating module 100b determines the first detected rotating speed value R1 as the rotating speed value. When the third rotating speed difference value $\Delta R3$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first calculating module 100b determines the second detected rotating speed value R2 as the rotating speed value.

When neither the first current difference value $\Delta I1$ is less than the predetermined current difference threshold ΔI nor the first rotating speed difference value $\Delta R1$ is less than the predetermined rotating speed difference threshold ΔR , a big fault occurs in the system, then the control module 100g turns off the parking motor 10 after a predetermined delay time (for example, three seconds in one embodiment) and generates an alarm. Alternatively, the first calculating module 100b may query the predetermined correlation table of currents and rotating speeds according to the first detected current value $I1$ and the second detected current value $I2$ respectively to obtain a first queried rotating speed value $R1'$ and a second queried rotating speed value $R2'$, and then calculate a difference between the first detected rotating speed value $R1$ and the first queried rotating speed value $R1'$ to obtain a difference value $\Delta R1'$ and calculate a difference between the second detected rotating speed value $R2$ and the second queried rotating speed value $R2'$ to obtain a difference value $\Delta R2'$. When the difference value $\Delta R1'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first calculating module 100b determines the first detected current value $I1$ and the first detected rotating speed value $R1$ as the current value and the rotating speed value for emergency usage. When the difference value $\Delta R2'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first calculating module 100b determines the second detected current value $I2$ and the second detected rotating speed value $R2$ as the current value and the rotating speed value for emergency usage. Alternatively, the first calculating module 100b may query the predetermined correlation table of currents and rotating speeds according to the first detected rotating speed value $R1$ and the second detected rotating speed value $R2$ respectively and then executes the processes similar to the above description to determine the current value and the rotating speed value for emergency usage, which will be omitted herein for simplicity.

The second calculating module 100d is configured to calculate a difference between the first temperature value $T1$ and the second temperature value $T2$ to obtain a temperature difference value $\Delta T1$, to compare the temperature difference value $\Delta T1$ with a predetermined temperature difference threshold ΔT to obtain a comparison result, and to determine a temperature value of the parking motor 10 according to the comparison result. Specifically, when the temperature difference value $\Delta T1$ is less than or equal to the predetermined temperature difference threshold ΔT , the second calculating module 100d calculates an average value of the first detected temperature value $T1$ and the second detected temperature value $T2$ as the temperature value of the parking motor 10.

When the temperature difference value $\Delta T1$ is greater than the predetermined temperature difference threshold ΔT , the second calculating module 100d chooses one having a larger absolute value from the first detected temperature value $T1$ and the second detected temperature value $T2$ as the temperature value of the parking motor 10, and meanwhile the control module 100g generates an alarm.

The reference table storage module 100e is configured to store a reference table indicating corresponding relationships between currents, rotating speeds, temperatures and torques of the parking motor 10.

The braking force calculating module 100f is configured to query the reference table according to the current value, the rotating speed value and the temperature value of the parking motor 10 so as to determine the output torque of the parking motor 10, and thus the braking force applied by the parking motor 10 is determined.

The control module 100g is further configured to control the parking motor 10 according to the determined braking force.

Fig. 3 is a flow chart of a method for controlling an electronic parking brake system according to embodiments of the present disclosure. As shown in Fig. 3, the method comprises the following steps.

At step 101, a first detected current value $I1$, a second detected current value $I2$, a first detected rotating speed value $R1$ and a second detected rotating speed value $R2$ are obtained. Specifically, the current of a parking motor is detected by a sensing element to obtain the first detected current value $I1$, the rotating speed of the parking motor is detected by a speed sensor to obtain the first detected rotating speed value $R1$, and the second detected current value $I2$ and the second detected rotating speed value $R2$ are obtained according to the voltage across a sampling resistor connected with the parking motor.

When the parking command is performed by the parking switch, a rotating force of the parking motor 10 is converted to a linear motion of the screw 25 via the gear train 20 and the threaded sleeve 30, and the parking cable 40 fastened at an end of the screw 25 is stretched by the linear motion of the screw 25. When a tension force of the brake reaches a target braking force, the vehicle is kept stable.

The tension force of the brake is controlled by the ECU 100. When the parking switch works and commands to tighten the parking cable 40, the controlling process starts, the circuit loop of the

parking motor is switched on, the parking motor 10 starts to rotate forwardly, and the counter starts to time, the sensing element detects the first detected current value I1 and the second detected current value I2 is obtained according to an amplified signal of the voltage across the sampling resistor.

5 As describe above, the first detected current value I1 can be obtained by the sensing element. The sensing element is small in size and may be integrated in the circuit board without involving in the circuit loop of the parking motor. The reliability of the current value detected by the sensing element is high. The second detected current value I2 is calculated after amplifying the voltage across the sampling resistor by an amplifier. The sampling resistor is generally a copper plate.

10 As described above, the rotating speed value of the parking motor can be detected by two different methods. One method is to integrate the speed sensor in the parking motor, and thus it is easy to directly read the value of the speed sensor to obtain the first detected rotating speed value R1. The other method is to use the sampling resistor. Specifically, firstly, a ripple voltage across the sampling resistor is amplified with a larger amplification coefficient to obtain a number of
15 changes occurring in a commutator bar of the parking motor, and then the number of commutations is divided by a number of commutations per circle to obtain the second detected rotating speed value R2.

At step 102, the difference between the first detected current value I1 and the second detected current value I2 is calculated to obtain the first current difference value $\Delta I1$, and the difference
20 between the first detected rotating speed value R1 and the second detected rotating speed value R2 is calculated to obtain the first rotating speed difference value $\Delta R1$.

At step 103, the first current difference value $\Delta I1$ is compared with the predetermined current difference threshold ΔI to obtain a first comparison result, and the first rotating speed difference value $\Delta R1$ is compared with a predetermined rotating speed difference threshold ΔR to obtain a
25 second comparison result.

As described above, the difference between two detected current values are compared with the predetermined current difference threshold ΔI and the difference between two detected rotating speed values are compared with a predetermined rotating speed difference threshold ΔR to determine whether the two detected current values and the two detected rotating speed values are
30 within the usable range. Herein, the term “usable” means that the first current difference value $\Delta I1$ is less than or equal to the predetermined current difference threshold ΔI and the first rotating

speed difference value $\Delta R1$ is less than or equal to the predetermined rotating difference threshold ΔR .

At step 104, the current value is determined according to the first comparison result and the rotating speed value is determined according to the second comparison result.

5 Specifically, when the first current difference value $\Delta I1$ is less than or equal to the predetermined current difference threshold ΔI and the first rotating speed difference value $\Delta R1$ is less than or equal to the predetermined rotating speed difference threshold ΔR , everything is normal, then the first detected current value $I1$ may be determined as the current value and the first detected rotating speed value $R1$ may be determined as the rotating speed value to calculate the
10 braking force.

When the first current difference value $\Delta I1$ is not less than the predetermined current difference threshold ΔI but the first rotating speed difference value $\Delta R1$ is less than or equal to the predetermined rotating speed difference threshold ΔR , a single fault alarm is generated, and a predetermined correlation table of currents and rotating speeds is queried according to the first
15 detected rotating speed value $R1$ or the second detected rotating speed value $R2$ to obtain a standard current value $I3$, a difference between the first detected current value $I1$ and the standard current value $I3$ is calculated to obtain a second current difference value $\Delta I2$ and a difference between the second detected current value $I2$ and the standard current value $I3$ is calculated to obtain a third current difference value $\Delta I3$. When the second current difference value $\Delta I2$ is less
20 than or equal to the predetermined current difference threshold ΔI , the first detected current value $I1$ is determined as the current value. When the third current difference value $\Delta I3$ is less than or equal to the predetermined current difference threshold ΔI , the second detected current value $I2$ is determined as the current value.

Similarly, when the first current difference value $\Delta I1$ is less than or equal to the
25 predetermined current difference threshold ΔI but the first rotating speed difference value $\Delta R1$ is not less than the predetermined rotating speed difference threshold ΔR , a single fault alarm is generated, and the predetermined correlation table of currents and rotating speeds is queried according to the first detected current value $I1$ or the second detected current value $I2$ to obtain a standard rotating speed value $R3$, a difference between the first detected rotating speed value $R1$
30 and the standard rotating speed value $R3$ is calculated to obtain a second rotating speed difference value $\Delta R2$ and a difference between the second detected rotating speed value $R2$ and the standard

rotating speed value $R3$ is calculated to obtain a third rotating speed difference value $\Delta R3$. When the second rotating speed difference value $\Delta R2$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first detected rotating speed value $R1$ is determined as the rotating speed value. When the third rotating speed difference value $\Delta R3$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the second detected rotating speed value $R2$ is determined as the rotating speed value.

When neither the first current difference value $\Delta I1$ is less than the predetermined current difference threshold ΔI nor the first rotating speed difference value $\Delta R1$ is less than the predetermined rotating speed difference threshold ΔR , a big fault occurs in the system, then the parking motor 10 is controlled to be turned off after a predetermined delay time (for example, three seconds in one embodiment) and an alarm is generated. Alternatively, the predetermined correlation table of currents and rotating speeds may be queried according to the first detected current value $I1$ and the second detected current value $I2$ respectively to obtain a first queried rotating speed value $R1'$ and a second queried rotating speed value $R2'$, and then a difference between the first detected rotating speed value $R1$ and the first queried rotating speed value $R1'$ is calculated to obtain a difference value $\Delta R1'$ and a difference between the second detected rotating speed value $R2$ and the second queried rotating speed value $R2'$ is calculated to obtain a difference value $\Delta R2'$. When the difference value $\Delta R1'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first detected current value $I1$ and the first detected rotating speed value $R1$ are determined as the current value and the rotating speed value for emergency usage. When the difference value $\Delta R2'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the second detected current value $I2$ and the second detected rotating speed value $R2$ are determined as the current value and the rotating speed value for emergency usage. Alternatively, the predetermined correlation table of currents and rotating speeds may be queried according to the first detected rotating speed value $R1$ and the second detected rotating speed value $R2$ respectively and then the processes similar to the above description may be executed to determine the current value and the rotating speed value for emergency usage, which will be omitted herein for simplicity.

At step 105, a first temperature value $T1$ of the parking motor is calculated according to a maximum current value when the parking motor is started and a second temperature value $T2$ of the parking motor is calculated according to a working current and a working time of the parking

motor.

As described above, the temperature of the parking motor can be measured by two different methods. One method is to calculate the first temperature value T1 of the parking motor according to the maximum current value when the parking motor is started. Specifically, a winding resistance of the parking motor is firstly obtained by dividing the voltage (measurable) of the parking motor by the maximum current value, and then the first temperature value T1 can be obtained according to the winding resistance, since the winding resistance of the parking motor changes with the temperature. The other method is to calculate the second temperature value T2 of the parking motor according to the working current and the working time of the parking motor. Specifically, firstly, a total power of the parking motor is calculated according to the voltage, the working current, the working time and the time interval of the parking motor, and an output force is calculated according to the current value and the rotating speed value of the parking motor so as to determine a mechanical power of the parking motor, and then a heat energy generated by the parking motor is obtained by subtracting the mechanical power from the total power, finally, the second temperature value T2 of the parking motor can be estimated by subtracting the heat dissipation during the time interval from the heat energy. The mechanical power may have a certain deviation, but the deviation only has a very little effect on the power difference value. When the current is used to calculate the output force of the parking motor, considering the influence of the temperature on the parking motor, an output torque of the parking motor corresponding to the current value may change slightly. Furthermore, when the torque is constant, the higher the temperature is, the greater the rotating speed change corresponding to a unit torque is. Thus, by detecting the temperature of the parking motor, the deviation of the output force of the parking motor can be corrected. When the temperature is too high or too low, in order to obtain a same braking force, certain corrected values of the current and the rotating speed are required.

At step 106, a difference between the first temperature value T1 and the second temperature value T2 is calculated to obtain a temperature difference value ΔT .

At step 107, the temperature difference value ΔT is compared with a predetermined temperature difference threshold ΔT to obtain a third comparison result and a temperature value of the parking motor is determined according to the third comparison result.

Specifically, when the temperature difference value ΔT is less than or equal to the predetermined temperature difference threshold ΔT , an average value of the first detected

temperature value T1 and the second detected temperature value T2 is calculated as the temperature value of the parking motor.

When the temperature difference value ΔT is greater than the predetermined temperature difference threshold ΔT , one having a larger absolute value from the first detected temperature value T1 and the second detected temperature value T2 is chosen as the temperature value of the parking motor and an alarm is generated.

At step 108, a predetermined reference table is queried according to the current value, the rotating speed value and the temperature value of the parking motor to determine a braking force applied by the parking motor.

Specifically, a reference table indicating corresponding relationships between currents, rotating speeds, temperatures and torques of the parking motor can be stored in a storage module of a single-chip. Thus, it is possible to query the reference table according to the above current value, rotating speed value and temperature value of the parking motor to obtain the output torque of the parking motor, thus determining the braking force.

At step 109, the parking motor is controlled according to the determined braking force.

Fig. 4 is a flow chart of a method for controlling an electronic parking brake system according to another embodiment of the present disclosure. As shown in Fig. 4, the method comprises the following steps.

At step 401, the electronic parking brake system starts to work.

At step 402, the electronic parking brake equipment is operated and the timing is started.

At step 403, the first detected current value I1 of the parking motor 10 is obtained. Specifically, the current of the parking motor 10 is detected by the sensing element to obtain the first detected current value I1.

At step 404, the second detected current value I2 of the parking motor 10 is obtained. Specifically, the second detected current value I2 is obtained according to the voltage across the sampling resistor connected with the parking motor.

At step 405, the first detected rotating speed value R1 of the parking motor 10 is obtained. Specifically, the rotating speed of the parking motor 10 is detected by the speed sensor to obtain the first detected rotating speed value R1.

At step 406, the second detected rotating speed value R2 of the parking motor 10 is obtained. Specifically, the second detected rotating speed value R2 of the parking motor 10 is obtained

according to the voltage across the sampling resistor connected with the parking motor.

At step 407, it is determined whether the difference value $\Delta I1$ between the first detected current value $I1$ and the second detected current value $I2$ is within the predetermined current error range $\{\Delta I\}$.

5 At step 408, it is determined whether the difference value $\Delta R1$ between the first detected rotating speed value $R1$ and the second detected rotating speed value $R2$ is within the predetermined rotating speed error range $\{\Delta R\}$.

At step 409, the parking motor is turned off after the predetermined delay time and then step 417 is executed when $\Delta I1 \notin \{\Delta I\}$ and $\Delta R1 \notin \{\Delta R\}$. In one embodiment, the predetermined delay
10 time is three seconds. When one detected current value and one detected rotating speed value are abnormal, a big fault occurs in the system, and the parking motor should be turned off. Alternatively, the predetermined correlation table of currents and rotating speeds may be queried according to the first detected current value $I1$ and the second detected current value $I2$ respectively to obtain a first queried rotating speed value $R1'$ and a second queried rotating speed
15 value $R2'$, and then a difference between the first detected rotating speed value $R1$ and the first queried rotating speed value $R1'$ is calculated to obtain a difference value $\Delta R1'$ and a difference between the second detected rotating speed value $R2$ and the second queried rotating speed value $R2'$ is calculated to obtain a difference value $\Delta R2'$. When the difference value $\Delta R1'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the first detected current value
20 $I1$ and the first detected rotating speed value $R1$ can be determined as the current value and the rotating speed value for emergency usage. When the difference value $\Delta R2'$ is less than or equal to the predetermined rotating speed difference threshold ΔR , the second detected current value $I2$ and the second detected rotating speed value $R2$ can be determined as the current value and the rotating speed value for emergency usage. Alternatively, the predetermined correlation table of
25 currents and rotating speeds may be queried according to the first detected rotating speed value $R1$ and the second detected rotating speed value $R2$ respectively and then the processes similar to the above description may be executed to determine the current value and the rotating speed value for emergency usage, which will be omitted herein for simplicity.

At step 410, a single fault alarm is generated when $\Delta I1 \notin \{\Delta I\}$ but $\Delta R1 \in \{\Delta R\}$ and then step
30 413 is executed.

At step 411, a single fault alarm is generated when $\Delta I1 \in \{\Delta I\}$ but $\Delta R1 \notin \{\Delta R\}$ and then step

414 is executed.

At step 412, the first detected current value I1 is determined as the current value of the parking motor, and the first detected rotating speed value R1 is determined as the rotating speed value of the parking motor, and then step 420 is executed.

5 At step 413, a standard current value I3 is obtained according to the first detected rotating speed value R1 or the second detected rotating speed value R2 and then step 415 is executed. Specifically, the predetermined correlation table of currents and rotating speeds is queried according to the first detected rotating speed value R1 or the second detected rotating speed value R2 to obtain the standard current value I3.

10 At step 414, a standard rotating speed value R3 is obtained according to the first detected current value I1 or the second detected current value I2 and then step 416 is executed. Specifically, the predetermined correlation table of currents and rotating speeds is queried according to the first detected current value I1 or the second detected current value I2 to obtain the standard rotating speed value R3.

15 At step 415, it is determined whether a difference $\Delta I2$ between the first detected current value I1 and the standard current value I3 or a difference $\Delta I3$ between the second detected current value I2 and the standard current value I3 is within the predetermined current error range $\{\Delta I\}$. When neither $\Delta I2$ nor $\Delta I3$ is within the predetermined current error range $\{\Delta I\}$, step 417 is executed. When either $\Delta I2$ or $\Delta I3$ is within the predetermined current error range $\{\Delta I\}$, step 418 is executed.

20 At step 416, it is determined whether a difference $\Delta R2$ between the first detected rotating speed value R1 and the standard rotating speed value R3 or a difference $\Delta R3$ between the second detected rotating speed value R2 and the standard rotating speed value R3 is within the predetermined rotating speed error range $\{\Delta R\}$. When neither $\Delta R2$ nor $\Delta R3$ is within $\{\Delta R\}$, step 417 is executed. When either $\Delta R2$ or $\Delta R3$ is within $\{\Delta R\}$, step 419 is executed.

25 At step 417, a serious fault alarm is generated.

At step 418, the first detected rotating speed value R1 is determined as the rotating speed value of the parking motor, and the detected current value Ix which satisfies $|Ix - I3| \in \{\Delta I\}$ is determined as the current value of the parking motor, and then step 420 is executed. Specifically, when the difference $\Delta I2$ is within the predetermined current error range $\{\Delta I\}$, the first detected current value I1 is determined as the current value. When the difference $\Delta I3$ is within the predetermined current error range $\{\Delta I\}$, the second detected current value I2 is determined as the

30

current value.

At step 419, the first detected current value $I1$ is determined as the current value of the parking motor, and the detected rotating speed value R_x which satisfies $|R_x - R3| \in \{\Delta R\}$ is determined as the rotating speed value of the parking motor, and then step 420 is executed.

5 Specifically, when the difference $\Delta R2$ is within the predetermined rotating speed error range $\{\Delta R\}$, the first detected rotating speed value $R1$ is determined as the rotating speed value. When the difference $\Delta R3$ is within the predetermined rotating speed error range $\{\Delta R\}$, the second detected rotating speed value $R2$ is determined as the rotating speed value.

At step 420, the temperature value of the parking motor is estimated.

10 In the present disclosure, firstly, a first temperature value $T1$ is calculated according to the maximum current value when the parking motor is started and a second temperature value $T2$ is calculated according to the working current and the working time of the parking motor, and then a difference value $\Delta T1$ between the first temperature value $T1$ and the second temperature value $T2$ is compared with the predetermined temperature difference threshold ΔT . When the temperature
15 difference value $\Delta T1$ is less than or equal to the predetermined temperature difference threshold ΔT , an average value of the first detected temperature value $T1$ and the second detected temperature value $T2$ is calculated as the temperature value of the parking motor. When the temperature difference value $\Delta T1$ is greater than the predetermined temperature difference threshold ΔT , one having a larger absolute value from the first detected temperature value $T1$ and
20 the second detected temperature value $T2$ is chosen as the temperature value of the parking motor. Specifically, a winding resistance of the parking motor can be firstly obtained by dividing the voltage (measurable) of the parking motor by the maximum current value, and then the first temperature value $T1$ can be obtained according to the winding resistance, since the winding resistance of the parking motor changes with the temperature. On the other hand, firstly, a total
25 power of the parking motor is calculated according to the voltage, the working current, the working time and the time interval of the parking motor, and an output force is calculated according to the current value and the rotating speed value of the parking motor so as to determine a mechanical power of the parking motor, and then a heat energy generated by the parking motor is obtained by subtracting the mechanical power from the total power, finally, the second temperature
30 value $T2$ of the parking motor 10 can be estimated by subtracting the heat dissipation during the time interval from the heat energy. The mechanical power may have a certain deviation, but the

deviation only has a very little effect on the power difference value. When the current is used to calculate the output force of the parking motor, considering the influence of the temperature on the parking motor, an output torque of the parking motor corresponding to the current value may change slightly. Furthermore, when the torque is constant, the higher the temperature is, the greater the rotating speed change corresponding to a unit torque is. Thus, by detecting the temperature of the parking motor, the deviation of the output force of the parking motor can be corrected. When the temperature is too high or too low, in order to obtain a same braking force, certain corrected values of the current and the rotating speed are required.

At step 421, the braking force applied to the brake is calculated.

Specifically, a reference table indicating corresponding relationships between currents, rotating speeds, temperatures and torques of the parking motor can be stored in a storage module of a single-chip. Thus, it is possible to query the reference table according to the above current value, rotating speed value and temperature value of the parking motor to obtain the output torque of the parking motor, thus determining the braking force.

At step 422, the parking motor is controlled according to the determined braking force.

With the method for controlling an electronic parking brake system according to embodiments of the present disclosure, since the current of the parking motor is detected by the sensing element and the sampling resistor connected with the parking motor respectively, and the rotating speed of the parking motor is detected by the speed sensor and the sampling resistor connected with the parking motor respectively, a dual protection for the current and the rotating speed is obtained, thus increasing an accuracy of the braking force (this is because the braking force is estimated according to a combination of the current and the rotating speed). Furthermore, since no other element for measuring force is used, a mechanical structure of the electronic parking brake system is simplified and a manufacturing cost of the electronic parking brake system is reduced.

Any process or method described in the flowing diagram or other means may be understood as a module, segment or portion including one or more executable instruction codes of the procedures configured to achieve a certain logic function or process, and the preferred embodiments of the present disclosure include other performances, in which the performance may be achieved in other orders instead of the order shown or discussed, such as in a almost simultaneous way or in an opposite order, which should be appreciated by those having ordinary

skills in the art to which embodiments of the present disclosure belong.

The logic and/or procedures indicated in the flowing diagram or described in other means herein, such as a constant sequence table of the executable code for performing a logical function, may be implemented in any computer readable storage medium so as to be adopted by the code execution system, the device or the equipment (such a system based on the computer, a system including a processor or other systems fetching codes from the code execution system, the device and the equipment , and executing the codes) or to be combined with the code execution system, the device or the equipment to be used. With respect to the description of the present invention, “the computer readable storage medium” may include any device including, storing, communicating, propagating or transmitting program so as to be used by the code execution system, the device and the equipment or to be combined with the code execution system, the device or the equipment to be used. The computer readable medium includes specific examples (a non-exhaustive list): the connecting portion (electronic device) having one or more arrangements of wire, the portable computer disc cartridge (a magnetic device), the random access memory (RAM), the read only memory (ROM), the electrically programmable read only memory (EPROMM or the flash memory), the optical fiber device and the compact disk read only memory (CDROM). In addition, the computer readable storage medium even may be papers or other proper medium printed with program, as the papers or the proper medium may be optically scanned, then edited, interpreted or treated in other ways if necessary to obtain the program electronically which may be stored in the computer memory.

It should be understood that, each part of the present invention may be implemented by the hardware, software, firmware or the combination thereof. In the above embodiments of the present invention, the plurality of procedures or methods may be implemented by the software or hardware stored in the computer memory and executed by the proper code execution system. For example, if the plurality of procedures or methods is to be implemented by the hardware, like in another embodiment of the present invention, any one of the following known technologies or the combination thereof may be used, such as discrete logic circuits having logic gates for implementing various logic functions upon an application of one or more data signals, application specific integrated circuits having appropriate logic gates, programmable gate arrays (PGA), field programmable gate arrays (FPGA).

It can be understood by those having the ordinary skills in the related art that all or part of the

steps in the method of the above embodiments can be implemented by instructing related hardware via programs, the program may be stored in a computer readable storage medium, and the program includes one step or combinations of the steps of the method when the program is executed.

In addition, each functional unit in the present disclosure may be integrated in one progressing module, or each functional unit exists as an independent unit, or two or more functional units may be integrated in one module. The integrated module can be embodied in hardware, or software. If the integrated module is embodied in software and sold or used as an independent product, it can be stored in the computer readable storage medium.

The computer readable storage medium may be, but not limited to read-only memories, magnetic disks, or optical disks.

Reference throughout this specification to “an embodiment,” “some embodiments,” “one embodiment,” “another example,” “an example,” “a specific example,” or “some examples,” means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the phrases such as “in some embodiments,” “in one embodiment,” “in an embodiment,” “in another example,” “in an example,” “in a specific example,” or “in some examples,” in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

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

What is claimed is:

1. A method for controlling an electronic parking brake system, comprising:

obtaining a first detected current value, a first detected rotating speed value, a second detected current value and a second detected rotating speed value of a parking motor;

5 calculating a difference between the first detected current value and the second detected current value to obtain a first current difference value and calculating a difference between the first detected rotating speed value and the second detected rotating speed value to obtain a first rotating speed difference value;

10 comparing the first current difference value with a predetermined current difference threshold to obtain a first comparison result and comparing the first rotating speed difference value with a predetermined rotating speed difference threshold to obtain a second comparison result;

determining a current value according to the first comparison result and determining a rotating speed value of the parking motor according to the second comparison result;

15 calculating a first temperature value of the parking motor according to a maximum current value when the parking motor is started and calculating a second temperature value of the parking motor according to a working current and a working time of the parking motor;

calculating a difference between the first temperature value and the second temperature value to obtain a temperature difference value;

20 comparing the temperature difference value with a predetermined temperature difference threshold to obtain a third comparison result, and determining a temperature value of the parking motor according to the third comparison result;

querying a predetermined reference table according to the current value, the rotating speed value and the temperature value of the parking motor to determine a braking force applied by the parking motor; and

25 controlling the parking motor according to the braking force.

2. The method according to claim 1, wherein determining a current value according to the first comparison result and determining a rotating speed value of the parking motor according to the second comparison result comprises:

30 when the first current difference value is less than or equal to the predetermined current difference threshold and the first rotating speed difference value is less than or equal to the predetermined rotating speed difference threshold, determining the first detected current value as

the current value and determining the first detected rotating speed value as the rotating speed value.

3. The method according to claim 1 or 2, wherein determining a current value according to the first comparison result and determining a rotating speed value of the parking motor according to the second comparison result comprises:

when the first current difference value is less than or equal to the predetermined current difference threshold and the first rotating speed difference value is greater than the predetermined rotating speed difference threshold, querying a predetermined correlation table of currents and rotating speeds according to the first detected current value or the second detected current value to obtain a standard rotating speed value;

calculating a difference between the first detected rotating speed value and the standard rotating speed value to obtain a second rotating speed difference value and calculating a difference between the second detected rotating speed value and the standard rotating speed value to obtain a third rotating speed difference value;

when the second rotating speed difference value is less than or equal to the predetermined rotating speed difference threshold, determining the first detected rotating speed value as the rotating speed value;

when the third rotating speed difference value is less than or equal to the predetermined rotating speed difference threshold, determining the second detected rotating speed value as the rotating speed value.

4. The method according to any of claims 1 to 3, wherein determining a current value according to the first comparison result and determining a rotating speed value of the parking motor according to the second comparison result comprises:

when the first current difference value is greater than the predetermined current difference threshold and the first rotating speed difference value is less than or equal to the predetermined rotating speed difference threshold, querying the predetermined correlation table of currents and rotating speeds according to the first detected rotating speed value or the second detected rotating speed value to obtain a standard current value;

calculating a difference between the first detected current value and the standard current value to obtain a second current difference value and calculating a difference between the second detected current value and the standard current value to obtain a third current difference value;

when the second current difference value is less than or equal to the predetermined current difference threshold, determining the first detected current value as the current value;

when the third current difference value is less than or equal to the predetermined current difference threshold, determining the second detected current value as the current value.

5 5. The method according to any of claims 1 to 4, further comprising:

when the first current difference value is greater than the predetermined current difference threshold and the first rotating speed difference value is greater than the predetermined rotating speed difference threshold, turning off the parking motor after a predetermined delay time and generating an alarm.

10 6. The method according to any of claims 1 to 5, wherein determining a temperature value of the parking motor according to the third comparison result comprises:

when the temperature difference value is less than or equal to the predetermined temperature difference threshold, calculating an average value of the first detected temperature value and the second detected temperature value as the temperature value of the parking motor;

15 when the temperature difference value is greater than the predetermined temperature difference threshold, choosing one having a larger absolute value from the first detected temperature value and the second detected temperature value as the temperature value of the parking motor.

20 7. The method according to any of claims 1-6, wherein the first detected current value is obtained from detecting a current of the parking motor by a sensing element, the first detected rotating speed value is obtained from detecting a rotating speed of the parking motor by a speed sensor, the second detected current value and the second detected rotating speed value are obtained according to a voltage across a sampling resistor connected with the parking motor.

25 8. An apparatus for controlling an electronic parking brake system, wherein the electronic parking brake system comprises a parking motor, a sensing element for detecting a current of a parking motor to obtain a first detected current value, a speed sensor for detecting a rotating speed of the parking motor to obtain a first detected rotating speed value, and a sampling resistor connected with the parking motor, and the apparatus comprises:

30 a first obtaining unit configured to read the first detected current value and the first detected rotating speed value and to obtain a second detected current value and a second detected rotating speed value according to a voltage across the sampling resistor;

a first calculating module configured to calculate a difference between the first detected current value and the second detected current value to obtain a first current difference value, to calculate a difference between the first detected rotating speed value and the second detected rotating speed value to obtain a first rotating speed difference value, to compare the first current difference value with a predetermined current difference threshold to obtain a first comparison result, to compare the first rotating speed difference value with a predetermined rotating speed difference threshold to obtain a second comparison result, to determine a current value of the parking motor according to the first comparison result, and to determine a rotating speed value of the parking motor according to the second comparison result;

a second obtaining module configured to obtain a maximum current value when the parking motor is started, a working current and a working time of the parking motor, to calculate a first temperature value of the parking motor according to the maximum current value when the parking motor is started and to calculate a second temperature value of the parking motor according to the working current and the working time of the parking motor;

a second calculating module configured to calculate a difference between the first temperature value and the second temperature value to obtain a temperature difference value, to compare the temperature difference value with a predetermined temperature difference threshold to obtain a third comparison result, and to determine a temperature value of the parking motor according to the third comparison result;

a reference table storage module configured to store a reference table indicating corresponding relationships between currents, rotating speeds, temperatures and torques of the parking motor;

a braking force calculating module configured to query the reference table according to the current value, the rotating speed value and the temperature value of the parking motor so as to determine the braking force applied by the parking motor; and

a control module configured to control the parking motor according to the determined braking force.

9. The apparatus according to claim 8, wherein the first calculating module is configured to:

determine the first detected current value as the current value and determine the first detected rotating speed value as the rotating speed value when the first current difference value is less than or equal to the predetermined current difference threshold and the first rotating speed difference

value is less than or equal to the predetermined rotating speed difference threshold.

10. The apparatus according to claim 8 or 9, wherein the first calculating module is configured to:

query a predetermined correlation table of currents and rotating speeds according to the first
5 detected current value or the second detected current value to obtain a standard rotating speed
value when the first current difference value is less than or equal to the predetermined current
difference threshold and the first rotating speed difference value is greater than the predetermined
rotating speed difference threshold;

calculate a difference between the first detected rotating speed value and the standard rotating
10 speed value to obtain a second rotating speed difference value and calculate a difference between
the second detected rotating speed value and the standard rotating speed value to obtain a third
rotating speed difference value;

determine the first detected rotating speed value as the rotating speed value when the second
rotating speed difference value is less than or equal to the predetermined rotating speed difference
15 threshold ; and

determine the second detected rotating speed value as the rotating speed value when the third
rotating speed difference value is less than or equal to the predetermined rotating speed difference
threshold.

11. The apparatus according to any of claims 8 to 10, wherein the first calculating module is
20 configured to:

query the predetermined correlation table of currents and rotating speeds according to the first
detected rotating speed value or the second detected rotating speed value to obtain a standard
current value when the first current difference value is greater than the predetermined current
difference threshold and the first rotating speed difference value is less than or equal to the
25 predetermined rotating speed difference threshold;

calculate a difference between the first detected current value and the standard current value
to obtain a second current difference value and calculate a difference between the second detected
current value and the standard current value to obtain a third current difference value;

determine the first detected current value as the current value when the second detected
30 current difference value is less than or equal to the predetermined current difference threshold; and

determine the second detected current value as the current value when the third detected

current difference value is less than or equal to the predetermined current difference threshold.

12. The apparatus according to any of claims 8 to 11, wherein the control module is further configured to turn off the parking motor after a predetermined delay time and generate an alarm when the first current difference value is greater than the predetermined current difference
5 threshold and the first rotating speed difference value is greater than the predetermined rotating speed difference threshold.

13. The apparatus according to any of claims 8 to 12, wherein the second calculating module is configured to:

calculate an average value of the first detected temperature value and the second detected
10 temperature value as the temperature value of the parking motor when the temperature difference value is less than or equal to the predetermined temperature difference threshold; and

choose one having a larger absolute value from the first detected temperature value and the second detected temperature value as the temperature value of the parking motor when the temperature difference value is greater than the predetermined temperature difference threshold.

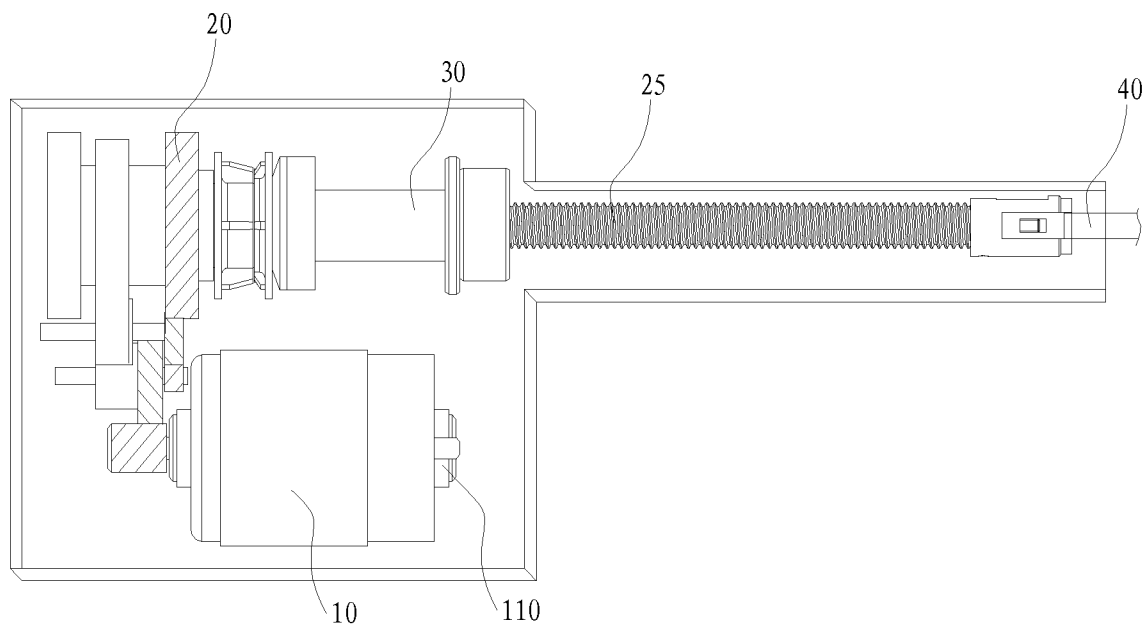


Fig. 1

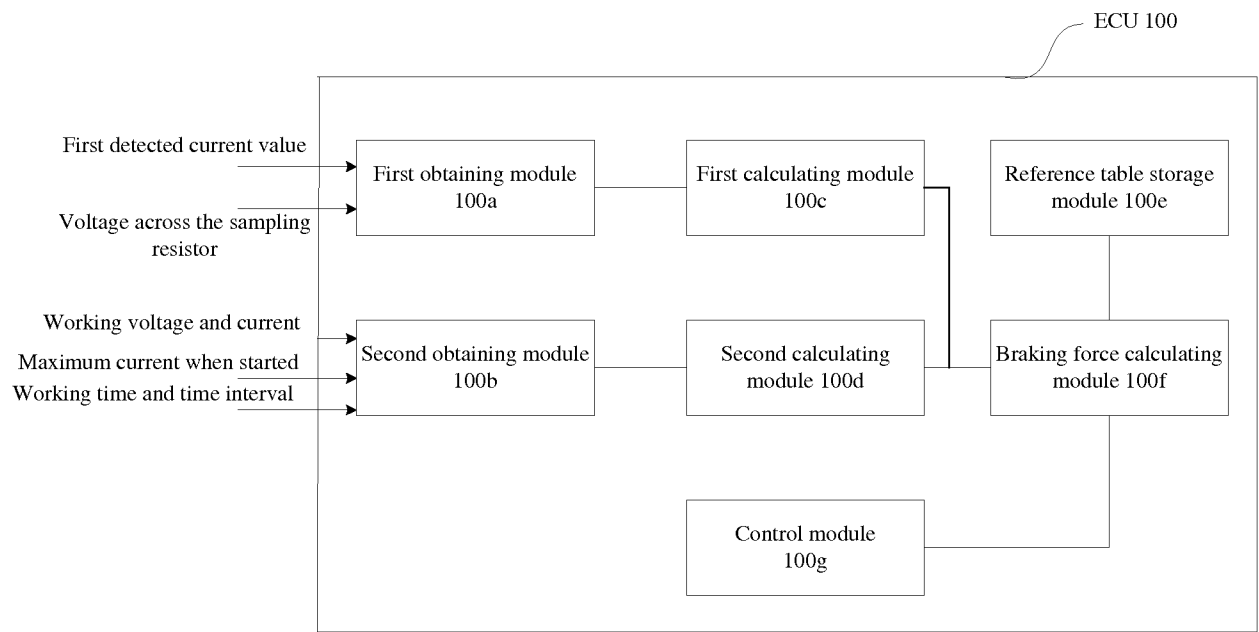


Fig. 2

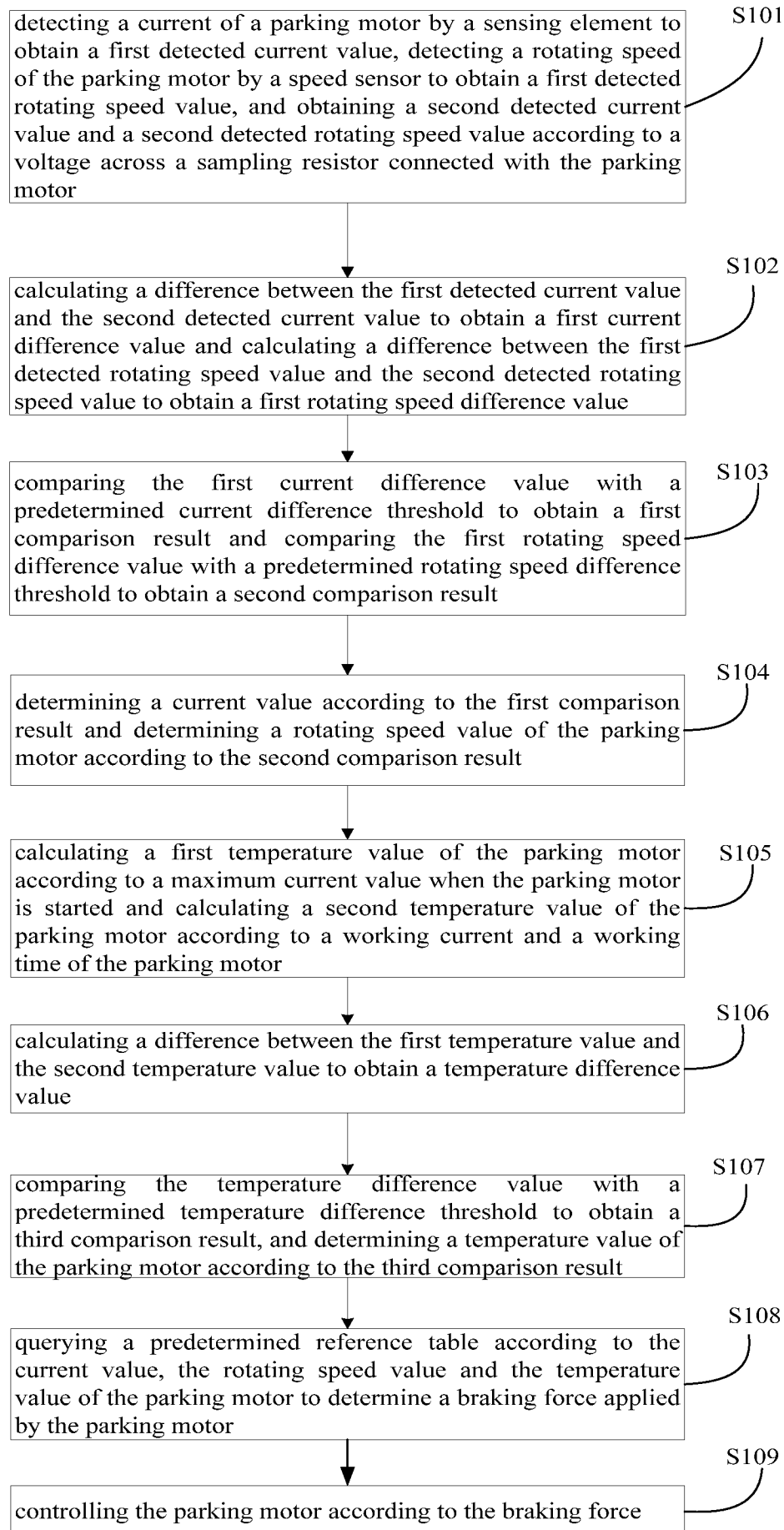


Fig. 3

I1: first detected current value
 I2: second detected current value
 R1: first detected rotating speed value
 R2: second detected rotating speed value
 I3: standard current value according to R1 or R2
 R3: standard rotating speed value according to I1 or I2
 $\{\Delta R\}$: predetermined rotating speed error range
 $\{\Delta I\}$: predetermined current error range
 $\Delta I2$: I1-I3
 $\Delta I3$: I2-I3
 $\Delta R2$: R1-R3
 $\Delta R3$: R2-R3

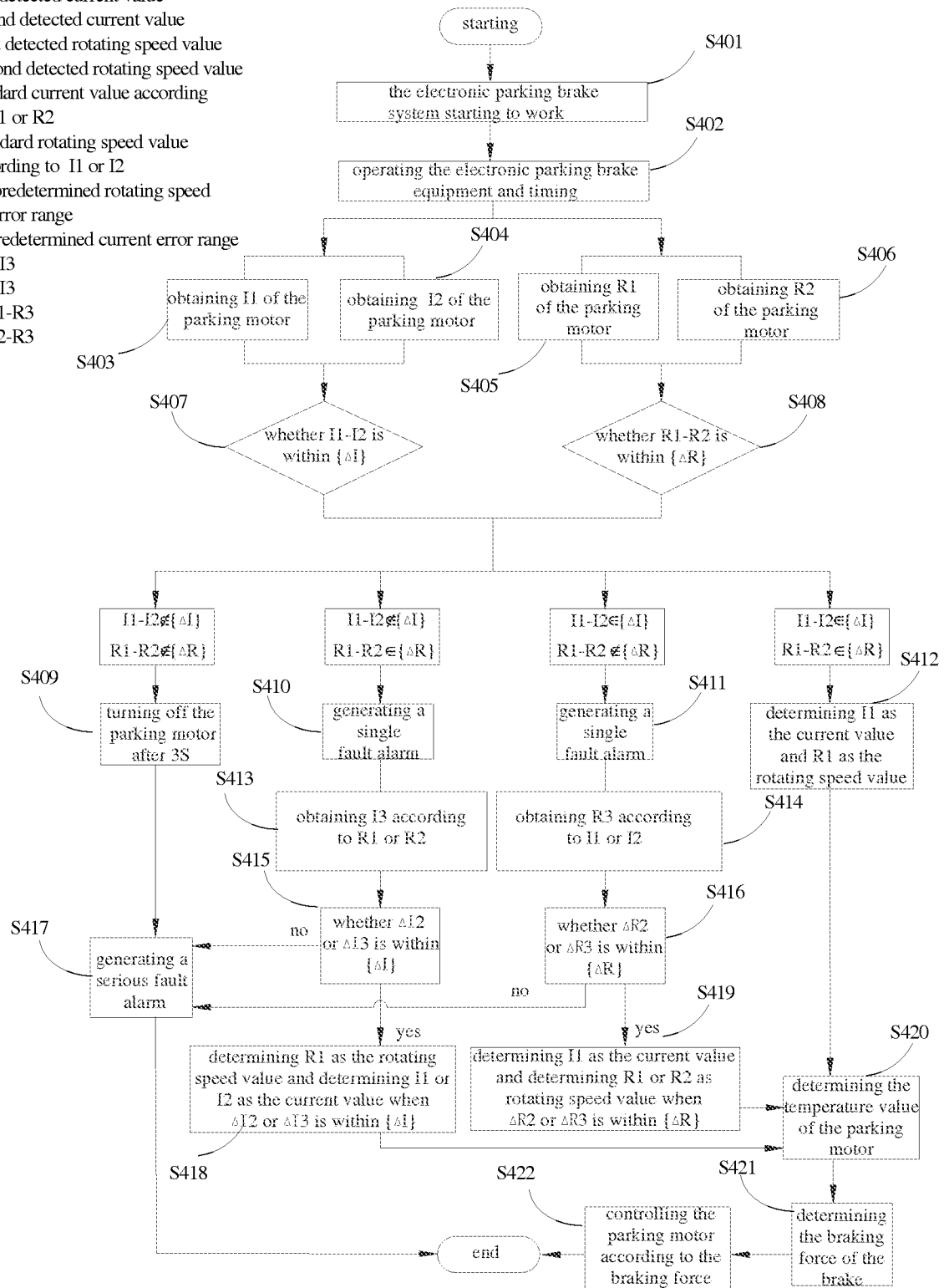


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/090883

A. CLASSIFICATION OF SUBJECT MATTER

B60T 8/17 (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: B60T; B60L

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)

WPI, EPODOC, CNPAT, IEEE, GOOGLE: electronic, park, brake, current, temperature, resistance, malfunction, fault, safety, different, compare, value, threshold, estimate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/0073423 A1 (MANDO CORPORATION) 31 March 2011 (31.03.2011) description, paragraph [0026]-[0078]	1-13
A	US 2008/0091326 A1 (HITACHI, LTD.) 17 April 2008 (17.04.2008) the whole document	1-13
A	DE 102005005720 A1 (ROBERT BOSCH GMBH) 17 August 2006(17.08.2006) the whole document	1-13
A	KR 10-2003-0045426 A (HYUNDAI MOTOR CO., LTD.) 11 June 2003(11.06.2003) the whole document	1-13

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

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Date of the actual completion of the international search 05 March 2014 (05.03.2014)	Date of mailing of the international search report 03 Apr. 2014 (03.04.2014)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer LAI, Yi Telephone No. (86-10)62413501

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