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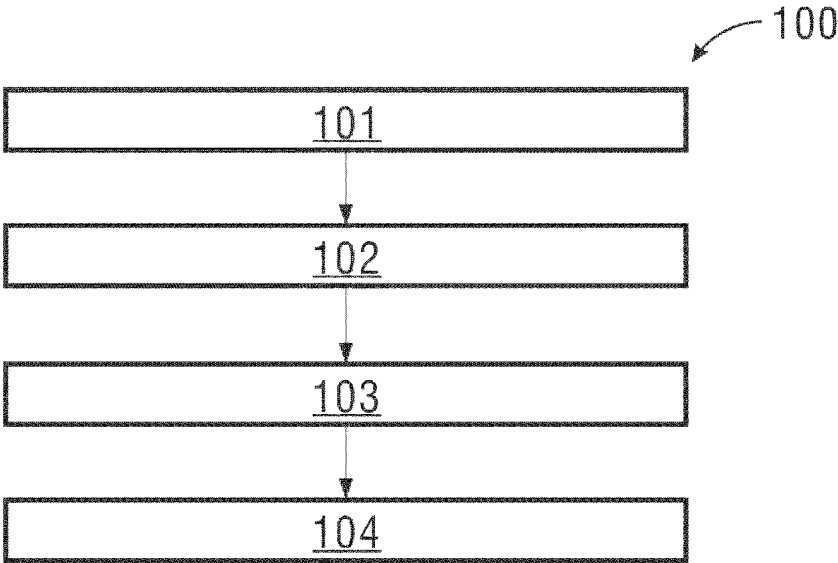


Fig. 1

(57) **Abstract:** The present application provides a motor control method and apparatus, an electronic device and storage medium. The motor control method comprises: acquiring a reactive current mean value of a permanent magnet synchronous motor; using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate; detecting a first reactive current value during operation of the permanent magnet synchronous motor; adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate. Controlling a permanent magnet synchronous motor by the motor control method provided in this solution can prevent the permanent magnet synchronous motor from falling out of step, and the permanent magnet synchronous motor is more stable during operation.

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Description**Motor control method and apparatus, electronic device and storage medium**

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Technical Field

The present application relates to the technical field of electric control, in particular to a motor control method and apparatus, an electronic device and a storage medium.

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Background Art

Permanent magnet synchronous motors have the advantages of high power efficiency, high power factor and small volume, and also have low rotational inertia, allowing high pulse torque, and are therefore capable of attaining high acceleration. Permanent magnet synchronous motors have good dynamic performance, are structurally compact and highly reliable in operation, while also being structurally simple and easy to maintain. As a result, permanent magnet synchronous motors are widely used in production as well as everyday life.

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At present, frequency converters employ vector control or programmable V/F control to drive permanent magnet synchronous motors.

However, the use of vector control to drive a permanent magnet synchronous motor is expensive, and when programmable V/F control is used, adjustment/testing is difficult due to the large number of types of permanent magnet synchronous motors and loads. Moreover, load changes easily cause permanent magnet synchronous motors to fall out of step, and permanent magnet synchronous motors have poor stability. Thus, existing motor control methods are not very practical.

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Summary of the Invention

In view of the above, the motor control method and apparatus, electronic device and storage medium provided in the present application can prevent a permanent magnet synchronous motor from falling out of step, and are thus highly practical.

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According to a first aspect of embodiments of the present application, a motor control method is provided, comprising: acquiring a reactive current mean value of a permanent magnet synchronous motor; using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate; detecting a first reactive current value during operation of the permanent magnet synchronous motor; adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

In a possible implementation, the step of acquiring a reactive current mean value of a permanent magnet synchronous motor comprises: acquiring a rated operating frequency of the permanent magnet synchronous motor; controlling the permanent magnet synchronous motor to operate at a first frequency, wherein the ratio of the first frequency to the rated operating frequency is a preset ratio threshold less than or equal to 1; detecting a reactive current of the permanent magnet synchronous motor, to obtain at least two second reactive current values; determining a mean value of the at least two second reactive current values to be the reactive current mean value.

In a possible implementation, the ratio threshold is $1/2$.

In a possible implementation, the step of using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate, comprises: acquiring a rated back emf voltage of the permanent magnet synchronous motor; determining the first output voltage corresponding to the target frequency according to a linear relationship between the rated operating frequency and the rated back emf voltage; using the first output voltage to drive the permanent magnet synchronous motor to operate, wherein the first output voltage is less than or equal to the rated back emf voltage.

In a possible implementation, the step of adjusting the first output voltage according to the first reactive current value and

the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises: if the difference between the first reactive current value and the reactive current mean value lies within a preset range of fluctuation, determining the first output voltage to be the second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

In a possible implementation, the step of adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises: if the difference between the first reactive current value and the reactive current mean value is greater than a first threshold, reducing the first output voltage to obtain the second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

In a possible implementation, the step of adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises: if the difference between the first reactive current value and the reactive current mean value is less than a second threshold, increasing the first output voltage to obtain the second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

According to a second aspect of embodiments of the present application, a motor control apparatus is provided, comprising: an acquisition unit, for acquiring a reactive current mean value of a permanent magnet synchronous motor; a first drive unit, for using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate; a detection unit, for detecting a first reactive current value during operation of the permanent magnet synchronous motor; a second drive unit, for adjusting the first output voltage

according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

5 According to a third aspect of embodiments of the present application, an electronic device is provided, comprising: a processor, a communication interface, a memory and a communication bus, the processor, the memory and the communication interface communicating with each other via the communication bus; the memory being configured to store at least one executable instruction, the executable instruction causing the processor to perform an operation corresponding to the motor control method provided in the first aspect above.

15 According to a fourth aspect of embodiments of the present application, a computer-readable storage medium is provided, wherein the computer-readable storage medium has stored thereon a computer instruction which, when executed by a processor, causes the processor to perform an operation corresponding to the motor control method provided in the first aspect above.

20 According to a fifth aspect of embodiments of the present application, a computer program product is provided, wherein the computer program product is tangibly stored on a computer-readable medium and comprises a computer-executable instruction which, when executed, causes at least one processor to perform the motor control method provided in the first aspect above or any possible implementation of the first aspect.

25 By means of the above technical solution, a first output voltage is used to drive a permanent magnet synchronous motor to operate, and in this way, independent voltage control of the permanent magnet synchronous motor is possible. The permanent magnet synchronous motor can be controlled more accurately to operate at a target frequency, and the first output voltage is adjusted according to a first reactive current detected during operation of the permanent magnet synchronous motor and an acquired reactive current mean value; thus, a drive voltage of the permanent magnet synchronous motor can be adjusted, so that the operation of the permanent magnet synchronous motor is more

stable. Since a non-vector control method is used to drive the permanent magnet synchronous motor, the cost is lower, and when the load changes, the output voltage (i.e. the drive voltage of the permanent magnet synchronous motor) can be changed automatically according to the reactive current value produced by the permanent magnet synchronous motor. Thus, the permanent magnet synchronous motor can be prevented from falling out of step, and stability is higher, so the motor control method is more practical.

Brief Description of the Drawings

Fig. 1 is a flow chart of a motor control method provided in embodiments of the present application.

Fig. 2 is a flow chart of a method provided in embodiments of the present application for acquiring a reactive current mean value.

Fig. 3 is a flow chart of another motor control method provided in embodiments of the present application.

Fig. 4 is a schematic drawing of a motor control apparatus provided in embodiments of the present application.

Fig. 5 is a schematic drawing of an electronic device provided in embodiments of the present application.

Key to the drawings:

101: acquiring a reactive current mean value of a permanent magnet synchronous motor

102: using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate

103: detecting a first reactive current value during operation of the permanent magnet synchronous motor

104: adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate

201: acquiring a rated operating frequency of the permanent

magnet synchronous motor

202: controlling the permanent magnet synchronous motor to operate at a first frequency

203: detecting a reactive current of the permanent magnet synchronous motor, to obtain at least two second reactive current values

204: determining a mean value of the at least two second reactive current values to be the reactive current mean value

301: calculating the difference between the first reactive current value and the reactive current mean value

302: judging whether the difference between the first reactive current value and the reactive current mean value is greater than a first threshold

303: reducing the first output voltage to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate

304: judging whether the difference between the first reactive current value and the reactive current mean value is less than a second threshold

305: increasing the first output voltage to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate

100: Motor control method 200: Method for acquiring reactive current mean value 300: Another motor control method

401: Acquisition unit 402: First drive unit 403: Detection unit

404: Second drive unit 500: Electronic device 502: Processor

504: Communication interface 506: Memory 508: Communication bus

510: Program 400: Motor control apparatus

Detailed Description of the Invention

As stated above, permanent magnet synchronous motors have the advantages of high power efficiency, high power factor and

small volume, and also have low rotational inertia, allowing high pulse torque, and are therefore capable of attaining high acceleration. Permanent magnet synchronous motors have good dynamic performance, are structurally compact and highly reliable in operation, while also being structurally simple and easy to maintain. As a result, permanent magnet synchronous motors are widely used in production as well as everyday life. At present, frequency converters employ vector control or programmable V/F control to drive permanent magnet synchronous motors. However, in the case of wind turbine and water pump type loads with quadratic torque load characteristics, the use of a large number of vector frequency converters to drive permanent magnet synchronous motors by vector control is expensive. Moreover, when programmable V/F control is used to drive a permanent magnet synchronous motor, the method of programmable V/F control is a minimum current method, in which a voltage value at an optimum operating point is found, and a V/F curve between voltage and frequency is determined according to the voltage value at the optimum operating point, and the permanent magnet synchronous motor is driven by means of the V/F curve. However, such a method has the following shortcomings: when the load changes, the optimum operating point also changes, and the use of the original V/F curve to drive the permanent magnet synchronous motor is likely to cause the permanent magnet synchronous motor to fall out of step. Permanent magnet synchronous motors have poor stability, and are difficult to adjust/test, so the adjustment/testing time is long. Thus, existing permanent magnet synchronous motor control methods are not very practical.

In embodiments of the present application, a first output voltage is used to drive a permanent magnet synchronous motor to operate, and in this way, independent voltage control of the permanent magnet synchronous motor is possible. The permanent magnet synchronous motor can be controlled more accurately to operate at a target frequency, and the first output voltage is adjusted according to a first reactive current detected during operation of the permanent magnet synchronous motor and an

acquired reactive current mean value; thus, a drive voltage of the permanent magnet synchronous motor can be adjusted, so that the operation of the permanent magnet synchronous motor is more stable. Since a non-vector control method is used to drive the permanent magnet synchronous motor, the cost is lower, and when the load changes, the output voltage (i.e. the drive voltage of the permanent magnet synchronous motor) can be changed automatically according to the reactive current value produced by the permanent magnet synchronous motor. Thus, the permanent magnet synchronous motor can be prevented from falling out of step, and stability is higher, so the motor control method is more practical.

The motor control method and apparatus and the electronic device provided in embodiments of the present application are explained in detail below with reference to the accompanying drawings.

Fig. 1 is a flow chart of a motor control method provided in embodiments of the present application. As shown in Fig. 1, the motor control method 100 comprises the following steps 101 - 104:

Step 101: acquiring a reactive current mean value of a permanent magnet synchronous motor.

A reactive current mean value of a permanent magnet synchronous motor connected to a frequency converter is acquired.

Optionally, it is possible to judge whether a reactive current mean value has been calculated in advance for the permanent magnet synchronous motor; if so, the reactive current mean value calculated in advance is acquired, otherwise a reactive current mean value of the permanent magnet synchronous motor is calculated, and the calculated reactive current mean value is acquired, wherein the reactive current mean value may be calculated by an integral calculation method, a mean value method or another calculation method, and the specific calculation method is not limited by embodiments of the present application.

Step 102: using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor

to operate.

The target frequency is a preset operating frequency of the permanent magnet synchronous motor, i.e. the permanent magnet synchronous motor is required to operate at the target frequency; in embodiments of the present application, the permanent magnet synchronous motor drive method is independent voltage drive, i.e. the frequency converter controls the operation of the permanent magnet synchronous motor by changing the output voltage.

The frequency converter determines the first output voltage corresponding to the target frequency, and drives the permanent magnet synchronous motor to operate by means of the first output voltage, so that the permanent magnet synchronous motor operates at the target frequency.

Step 103: detecting a first reactive current value during operation of the permanent magnet synchronous motor.

A first reactive current value arising during operation of the permanent magnet synchronous motor is detected; specifically, a drive current during operation of the permanent magnet synchronous motor may be split orthogonally into two current components at a first output voltage phase angle, wherein one current component has the same phase as the voltage, and the other current component is 90° from the voltage phase angle. The current component which has the same phase as the voltage is active current, and the current component which is 90° from the voltage phase angle is reactive current; and a first reactive current value of the reactive current is read. It should be understood that only one example of a method for detecting reactive current is shown above, and this should not be regarded as limiting the method for detecting reactive current in embodiments of the present application in any way.

Step 104: adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

The first output voltage is adjusted according to the first

reactive current value and the reactive current mean value, the process of adjustment comprising increasing the first output voltage, decreasing the first output voltage and maintaining the first output voltage, and the permanent magnet synchronous motor is driven to operate according to the second output voltage obtained by adjustment.

It must be explained that the process of adjusting the first output voltage is a dynamic adjustment process, i.e. after using the second output voltage to drive the permanent magnet synchronous motor, step 103 of detecting a first reactive current value during operation of the permanent magnet synchronous motor is performed again, and the second output voltage is adjusted according to the new first reactive current and the reactive current mean value; and this process is repeated.

In embodiments of the present application, a first output voltage is used to drive a permanent magnet synchronous motor to operate, and in this way, independent voltage control of the permanent magnet synchronous motor is possible. The permanent magnet synchronous motor can be controlled more accurately to operate at a target frequency, and the first output voltage is adjusted according to a first reactive current detected during operation of the permanent magnet synchronous motor and an acquired reactive current mean value; thus, a drive voltage of the permanent magnet synchronous motor can be adjusted, so that the operation of the permanent magnet synchronous motor is more stable. Since a non-vector control method is used to drive the permanent magnet synchronous motor, the cost is lower, and when the load changes, the output voltage (i.e. the drive voltage of the permanent magnet synchronous motor) can be changed automatically according to the reactive current value produced by the permanent magnet synchronous motor. Thus, the permanent magnet synchronous motor can be prevented from falling out of step, and stability is higher, so the motor control method is more practical.

Fig. 2 is a flow chart of a method provided in embodiments of the present application for acquiring a reactive current mean value; as shown in Fig. 2, when acquiring a reactive current

mean value of the permanent magnet synchronous motor, steps 201 - 204 below may be performed:

Step 201: acquiring a rated operating frequency of the permanent magnet synchronous motor.

5 The rated operating frequency of the permanent magnet synchronous motor is acquired; this rated operating frequency is recorded on a motor nameplate. The rated operating frequency recorded on the nameplate may be inputted manually. It should be explained that when the rated operating frequency of the
10 permanent magnet synchronous motor is not recorded on the motor nameplate, a rated rotation speed of the permanent magnet synchronous motor may be acquired, and the rated operating frequency of the permanent magnet synchronous motor may be calculated according to the formula $n = 60f/p$, where n is used to
15 represent the rated rotation speed of the permanent magnet synchronous motor, f is used to represent the rated operating frequency of the permanent magnet synchronous motor, and p is used to represent the number of pole pairs of the rotating magnetic field in the permanent magnet synchronous motor.

20 Step 202: controlling the permanent magnet synchronous motor to operate at a first frequency.

The permanent magnet synchronous motor is controlled to operate at the first frequency; in embodiments of the present application, a V/F control method is used to drive the permanent
25 magnet synchronous motor to operate at the first frequency, wherein the ratio of the first frequency to the rated operating frequency is a preset ratio threshold less than or equal to 1, for example: the ratio threshold may be 1/4, i.e. the first frequency is 1/4 of the rated frequency, and when the ratio
30 threshold is 1, the permanent magnet synchronous motor is driven to operate at the rated frequency.

Step 203: detecting a reactive current of the permanent magnet synchronous motor, to obtain at least two second reactive current values.

35 When operation of the permanent magnet synchronous motor reaches the first frequency, and operates stably at the first frequency, a reactive current of the permanent magnet

synchronous motor at this time is detected at least twice, to obtain at least two reactive current values.

Step 204: determining a mean value of the at least two second reactive current values to be the reactive current mean value.

5 The mean value of the at least two second reactive current values is calculated; in embodiments of the present application, various calculation methods can be used to calculate the mean value, for example: if there are a second reactive current 1 and a second reactive current 2, then the mean value is calculated
10 according to the formula (second reactive current 1 + second reactive current 2)/2 or the mean value is calculated by a geometric mean value calculation method, etc.

 The calculated mean value of the at least two second reactive currents is determined to be the reactive current mean value,
15 which is recorded.

 In embodiments of the present application, the permanent magnet synchronous motor is controlled to operate at the first frequency, the second reactive currents arising during operation of the permanent magnet synchronous motor are detected multiple
20 times, and the mean value of the second reactive currents is determined to be the reactive current mean value. In this way, the reactive current mean value can be acquired. Moreover, since the reactive current mean value is the mean value of multiple reactive currents arising during operation at a fixed frequency,
25 the reactive current mean value is more accurate and has higher reference significance; thus, when the first output voltage is adjusted according to the reactive current mean value and the first reactive current value, operation of the permanent magnet synchronous motor can be made more stable, so the method is more
30 practical.

 In a possible implementation, the ratio threshold is 1/2.

 In embodiments of the present application, the ratio of the first frequency to the rated operating frequency is 1 : 2, i.e. the permanent magnet synchronous motor is controlled to operate
35 at 1/2 of the rated frequency; in this case, the reactive current mean value calculated according to multiple second reactive currents produced by operation of the permanent magnet

synchronous motor has greater reference significance, and the reactive current mean value is more accurate.

In a possible implementation, when the first output voltage corresponding to the target frequency is used to drive the permanent magnet synchronous motor to operate, a rated back emf voltage of the permanent magnet synchronous motor may be acquired, then the first output voltage corresponding to the target frequency is determined according to a linear relationship between the rated operating frequency and the rated back emf voltage, and the first output voltage is used to drive the permanent magnet synchronous motor to operate, wherein the first output voltage is less than or equal to the rated back emf voltage.

The rated back emf voltage of the permanent magnet synchronous motor is acquired; specifically, the rated back emf voltage of the permanent magnet synchronous motor may be calculated automatically according to nameplate data of the permanent magnet synchronous motor inputted to the frequency converter, in which case the rated back emf voltage is a rated input voltage of the permanent magnet synchronous motor.

The first output voltage corresponding to the target frequency is determined according to the linear relationship between the rated operating frequency and the rated back emf voltage; since a linear relationship, specifically a directly proportional relationship exists between the rated operating frequency and the rated back emf voltage, the ratio of the rated operating frequency to the rated back emf voltage is a fixed constant, for example: the rated operating frequency is 50 Hz, and the rated back emf voltage is 300 V, so if the target frequency is 10 Hz at this time, then an input voltage of the permanent magnet synchronous motor is 60 V, i.e. the first output voltage of the frequency converter is 60 V.

If the input voltage of the permanent magnet synchronous motor exceeds the rated back emf voltage, this is likely to cause damage to the permanent magnet synchronous motor, so the target frequency is less than or equal to the rated operating frequency, and the input voltage of the permanent magnet

synchronous motor is less than or equal to the rated back emf voltage, i.e. the first output voltage of the frequency converter is less than or equal to the rated back emf voltage.

In embodiments of the present application, the first output
5 voltage corresponding to the target frequency is determined according to the linear relationship between the rated operating frequency and the rated back emf voltage of the permanent magnet synchronous motor, and the permanent magnet synchronous motor is driven to operate by means of the first output voltage, so
10 that the permanent magnet synchronous motor operates at the target frequency. Since the permanent magnet synchronous motor is driven to operate by controlling the first output voltage, the permanent magnet synchronous motor is controlled by independent voltage control, and control accuracy is higher than
15 when the permanent magnet synchronous motor is driven with a V/F control method.

Fig. 3 is a flow chart of another motor control method provided in embodiments of the present application. As shown in Fig. 3, based on steps 101 - 104 shown in Fig. 1, step 104
20 comprises the following steps 301 - 303:

Step 301: calculating the difference between the first reactive current value and the reactive current mean value.

Step 302: judging whether the difference between the first reactive current value and the reactive current mean value is
25 greater than a first threshold; if yes (Y), performing step 303, and if no (N), performing step 304.

Step 303: reducing the first output voltage to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, and
30 performing step 103.

When the difference between the first reactive current value and the reactive current mean value is greater than the first threshold, the first output voltage is reduced; the input current and input voltage of the permanent magnet synchronous
35 motor can thus be reduced, and the second output voltage obtained by reducing the first output voltage is used to drive the permanent magnet synchronous motor to operate, and step 103 of

detecting a first reactive current value during operation of the permanent magnet synchronous motor is performed again, so as to perform steps 301 - 303 again; and this cycle is repeated.

Step 304: judging whether the difference between the first
5 reactive current value and the reactive current mean value is less than a second threshold; if yes (Y), performing step 305, and if no (N), performing step 103.

Step 305: increasing the first output voltage to obtain a second output voltage, and using the second output voltage to
10 drive the permanent magnet synchronous motor to operate, and performing step 103.

When the difference between the first reactive current value and the reactive current mean value is less than the second threshold, the first output voltage is increased; the input
15 current and input voltage of the permanent magnet synchronous motor can thus be increased, and the second output voltage obtained by increasing the first output voltage is used to drive the permanent magnet synchronous motor to operate, and step 103 of detecting a first reactive current value during operation of
20 the permanent magnet synchronous motor is performed again, so as to perform steps 301 - 303 again; and this cycle is repeated.

It should be explained that when the difference between the first reactive current value and the reactive current mean value is less than the first threshold and greater than the second
25 threshold, i.e. the difference between the first reactive current value and the reactive current mean value lies within a preset range of fluctuation, the first output voltage is not changed, and is determined to be the second output voltage, and the second output voltage is used to drive the permanent magnet
30 synchronous motor to operate. The range of fluctuation is [first threshold, second threshold].

This embodiment is explained below, taking as an example the case where the first threshold is +0.05, the second threshold is -0.05, and the preset range of fluctuation is [-0.05, +0.05].

35 When $I_1 < I_0 - 0.05$, i.e. $I_1 - I_0 < -0.05$, the first output voltage is increased to obtain the second output voltage, and the second output voltage is used to drive the permanent magnet

synchronous motor to operate, and the step of detecting a first reactive current value arising when the second output voltage is used to drive the permanent magnet synchronous motor to operate is performed again, wherein I_1 is used to represent the first reactive current value, and I_0 is used to represent the reactive current mean value.

When $I_1 > I_0 + 0.05$, i.e. $I_1 - I_0 > +0.05$, the first output voltage is reduced to obtain the second output voltage, and the second output voltage is used to drive the permanent magnet synchronous motor to operate, and the step of detecting a first reactive current value arising when the second output voltage is used to drive the permanent magnet synchronous motor to operate is performed again.

When $I_0 - 0.05 < I_1 < I_0 + 0.05$, i.e. $-0.05 < I_1 - I_0 < +0.05$, the first output voltage is determined to be the second output voltage, and the second output voltage is used to drive the permanent magnet synchronous motor to operate.

It should be understood that the process described above is only one example, and does not limit the present application in any way; specifically, the first threshold, the second threshold and the preset range of fluctuation may be set according to the operating stability requirement of the permanent magnet synchronous motor.

In embodiments of the present application, the first output voltage is adjusted according to the difference between the first reactive current value and the reactive current mean value to obtain the second output voltage, and the second output voltage is used to drive the permanent magnet synchronous motor to operate. In this way, the permanent magnet synchronous motor can be controlled to find the optimum operating point automatically, reducing the difficulty of adjustment/testing. When the load changes, the output voltage can be adjusted dynamically, preventing the permanent magnet synchronous motor from falling out of step due to load changes, and increasing the operating stability of the permanent magnet synchronous motor; thus, the motor control method is more practical.

Fig. 4 is a schematic drawing of a motor control apparatus

provided in embodiments of the present application. As shown in Fig. 4, a motor control apparatus 400 comprises:

an acquisition unit 401, for acquiring a reactive current mean value of a permanent magnet synchronous motor;

5 a first drive unit 402, for using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate;

a detection unit 403, for detecting a first reactive current value during operation of the permanent magnet synchronous motor;

10 a second drive unit 404, for adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

15 In embodiments of the present application, the acquisition unit 401 may be used to perform step 101 in the method embodiments above, the first drive unit 402 may be used to perform step 102 in the method embodiments above, the detection unit 403 may be used to perform step 103 in the method
20 embodiments above, and the second drive unit 404 may be used to perform step 104 in the method embodiments above.

In a possible implementation, the acquisition unit 401 may be used to acquire a rated operating frequency of the permanent magnet synchronous motor; control the permanent magnet
25 synchronous motor to operate at a first frequency, wherein the ratio of the first frequency to the rated operating frequency is a preset ratio threshold less than or equal to 1; detect a reactive current of the permanent magnet synchronous motor, to obtain at least two second reactive current values; and
30 determine a mean value of the at least two second reactive current values to be the reactive current mean value.

In a possible implementation, the ratio threshold is 1/2.

In a possible embodiment, the acquisition unit 401 may be used to acquire a rated back emf voltage of the permanent magnet
35 synchronous motor; determine the first output voltage corresponding to the target frequency according to a linear relationship between the rated operating frequency and the rated

back emf voltage; and use the first output voltage to drive the permanent magnet synchronous motor to operate, wherein the first output voltage is less than or equal to the rated back emf voltage.

5 In a possible implementation, if the difference between the first reactive current value and the reactive current mean value lies within a preset range of fluctuation, the second drive unit 404 may determine the first output voltage to be the second output voltage, and use the second output voltage to drive the permanent magnet synchronous motor to operate.

10 In a possible implementation, if the difference between the first reactive current value and the reactive current mean value is greater than a first threshold, the second drive unit 404 may reduce the first output voltage to obtain the second output voltage, and use the second output voltage to drive the permanent magnet synchronous motor to operate.

15 In a possible implementation, if the difference between the first reactive current value and the reactive current mean value is less than a second threshold, the second drive unit 404 may increase the first output voltage to obtain the second output voltage, and use the second output voltage to drive the permanent magnet synchronous motor to operate.

20 It should be explained that content such as processes of execution and exchange of information between the modules in the motor control apparatus is based on the same concept as the motor control method embodiments above, so for specific content, reference may be made to the information related in the motor control method embodiments above, which is not repeated here.

25 Fig. 5 is a schematic drawing of an electronic device provided in embodiments of the present application. The specific embodiments of the present application do not limit the specific implementation of the electronic device. Referring to Fig. 5, the electronic device 500 provided in embodiments of the present application comprises: a processor 502, a communication interface 504, a memory 506 and a communication bus 508. Here:

35 The processor 502, the communication interface 504 and the memory 506 communicate with each other via the communication bus

508.

The communication interface 504 is configured to communicate with other electronic devices or servers.

The processor 502 is configured to execute a program 510,
5 and specifically may perform the relevant steps in any of the motor control method embodiments above.

Specifically, the program 510 may comprise program code, which comprises computer operation instructions.

The processor 502 may be a central processing unit (CPU), or
10 an application specific integrated circuit (ASIC), or one or more integrated circuit configured to implement the embodiments of the present application. One or more processors comprised in a smart device may be of the same type, for example, one or more CPUs; or of different types, for example, one or more CPUs and
15 one or more ASICs.

The memory 506 is configured to store the program 510. The memory 506 may comprise a high-speed RAM, and may further comprise a non-volatile memory, for example, at least one magnetic disk memory.

20 The program 510 may specifically be configured to cause the processor 502 to perform the motor control method in any of the embodiments above.

For the specific implementation of the steps in the program 510, reference may be made to the corresponding steps in any of
25 the motor control method embodiments above and the corresponding descriptions in the units, which are not described again here. Those skilled in the art will clearly understand that, for convenience and simplicity of description, for the specific operation processes of the device and modules described above,
30 reference may be made to the descriptions of corresponding processes in the method embodiments above, which are not repeated here.

By means of the electronic device in embodiments of the present application, a first output voltage is used to drive a
35 permanent magnet synchronous motor to operate, and in this way, independent voltage control of the permanent magnet synchronous motor is possible. The permanent magnet synchronous motor can

be controlled more accurately to operate at a target frequency, and the first output voltage is adjusted according to a first reactive current detected during operation of the permanent magnet synchronous motor and an acquired reactive current mean value; thus, a drive voltage of the permanent magnet synchronous motor can be adjusted, so that the operation of the permanent magnet synchronous motor is more stable. Since a non-vector control method is used to drive the permanent magnet synchronous motor, the cost is lower, and when the load changes, the output voltage (i.e. the drive voltage of the permanent magnet synchronous motor) can be changed automatically according to the reactive current value produced by the permanent magnet synchronous motor. Thus, the permanent magnet synchronous motor can be prevented from falling out of step, and stability is higher, so the motor control method is more practical.

Embodiments of the present application further provide a computer-readable storage medium, storing instructions for causing a machine to perform the motor control method as described herein. Specifically, a system or apparatus equipped with a storage medium may be provided; software program code realizing functions of any one of the embodiments above is stored on the storage medium, and a computer (or CPU or MPU) of the system or apparatus is caused to read and execute program code stored in the storage medium.

In this case, the program code read from the storage medium can itself implement the functions of any of the embodiments described above, and therefore the program code and the storage medium storing the program code constitute part of the present application.

Embodiments of storage media used for providing the program code include floppy disks, hard disks, magneto-optical disks, optical disks (such as CD-ROM, CD-R, CD-RW, DVD-ROM, DVD-RAM, DVD-RW, DVD+RW), magnetic tapes, non-volatile memory cards and ROM. Optionally, the program code may be downloaded from a server computer via a communication network.

Furthermore, it should be clarified that an operating system, etc. operating on a computer can be made to complete part or all

of actual operations, not only through execution of the program code read by a computer, but also by means of instructions based on the program code, so as to realize functions of any one of the embodiments above.

5 In addition, it will be understood that the program code read from the storage medium is written into a memory provided in an expansion board inserted into a computer or written into a memory provided in an expansion module connected to a computer, and then based on the instruction of the program code, a CPU, etc.
10 installed on the expansion board or the expansion module is made to perform part or all of the actual operations, thereby implementing the functions of any of the embodiments described above.

Embodiments of the present application further provide a
15 computer program product, which is tangibly stored on a computer-readable medium and includes computer-executable instructions which, when executed, cause at least one processor to perform the motor control method provided in the above embodiments. It should be understood that the solutions in this
20 embodiment have the corresponding technical effects in the method embodiments described above, which will not be detailed here.

It should be explained that not all of the steps and modules in the flows and system structure diagrams above are necessary;
25 certain steps or modules may be omitted according to actual requirements. The sequence in which the steps are executed is not fixed, and may be adjusted as needed. The system structures described in the embodiments above may be physical structures or logical structures, i.e., some modules might be realized by
30 the same physical entity, or some modules might be realized by multiple physical entities, or realized jointly by certain components in multiple independent devices.

A noun or pronoun referring to a person in the present patent application is not limited to a specific gender.

35 In the embodiments above, a hardware module may be realized in a mechanical or an electrical manner. For example, a hardware module may comprise permanent dedicated circuitry or logic (for

example, a dedicated processor, an FPGA or an ASIC) to perform corresponding operations. The hardware module may further comprise programmable logic or circuitry (for example, a general-purpose processor or other programmable processor), which may be temporarily configured by software to complete corresponding operations. Particular implementations (mechanical, or dedicated permanent circuitry, or temporarily set circuitry) may be determined based on considerations of cost and time.

The present application has been demonstrated and described in detail in conjunction with the drawings and preferred embodiments, but the present application is not limited to these disclosed embodiments. Those skilled in the art can understand that more embodiments of the present application can be obtained by combining the code review means in different embodiments described above based on the various embodiments above, and these embodiments also fall within the scope of protection of the present application.

Claims

1. A motor control method (100), comprising:

acquiring a reactive current mean value of a permanent magnet
5 synchronous motor;

using a first output voltage corresponding to a target
frequency to drive the permanent magnet synchronous motor to
operate;

10 detecting a first reactive current value during operation of
the permanent magnet synchronous motor;

adjusting the first output voltage according to the first
reactive current value and the reactive current mean value to
obtain a second output voltage, and using the second output
voltage to drive the permanent magnet synchronous motor to
15 operate.

2. The method as claimed in claim 1, wherein the step of
acquiring a reactive current mean value of a permanent magnet
synchronous motor comprises:

20 acquiring a rated operating frequency of the permanent magnet
synchronous motor;

controlling the permanent magnet synchronous motor to operate
at a first frequency, wherein the ratio of the first frequency
to the rated operating frequency is a preset ratio threshold
less than or equal to 1;

25 detecting a reactive current of the permanent magnet
synchronous motor, to obtain at least two second reactive
current values;

determining a mean value of the at least two second reactive
current values to be the reactive current mean value.

30 3. The method as claimed in claim 2, wherein the ratio
threshold is $1/2$.

4. The method as claimed in claim 2, wherein the step of
using a first output voltage corresponding to a target frequency
to drive the permanent magnet synchronous motor to operate,
35 comprises:

acquiring a rated back emf voltage of the permanent magnet
synchronous motor;

determining the first output voltage corresponding to the target frequency according to a linear relationship between the rated operating frequency and the rated back emf voltage;

5 using the first output voltage to drive the permanent magnet synchronous motor to operate, wherein the first output voltage is less than or equal to the rated back emf voltage.

10 5. The method as claimed in claim 1, wherein the step of adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises:

15 if the difference between the first reactive current value and the reactive current mean value lies within a preset range of fluctuation, determining the first output voltage to be the second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

20 6. The method as claimed in claim 1, wherein the step of adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises:

25 if the difference between the first reactive current value and the reactive current mean value is greater than a first threshold, reducing the first output voltage to obtain the second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

30 7. The method as claimed in claim 1, wherein the step of adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate, comprises:

35 if the difference between the first reactive current value and the reactive current mean value is less than a second threshold, increasing the first output voltage to obtain the

second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

8. A motor control apparatus (400), comprising:

an acquisition unit (401), for acquiring a reactive current mean value of a permanent magnet synchronous motor;

a first drive unit (402), for using a first output voltage corresponding to a target frequency to drive the permanent magnet synchronous motor to operate;

a detection unit (403), for detecting a first reactive current value during operation of the permanent magnet synchronous motor;

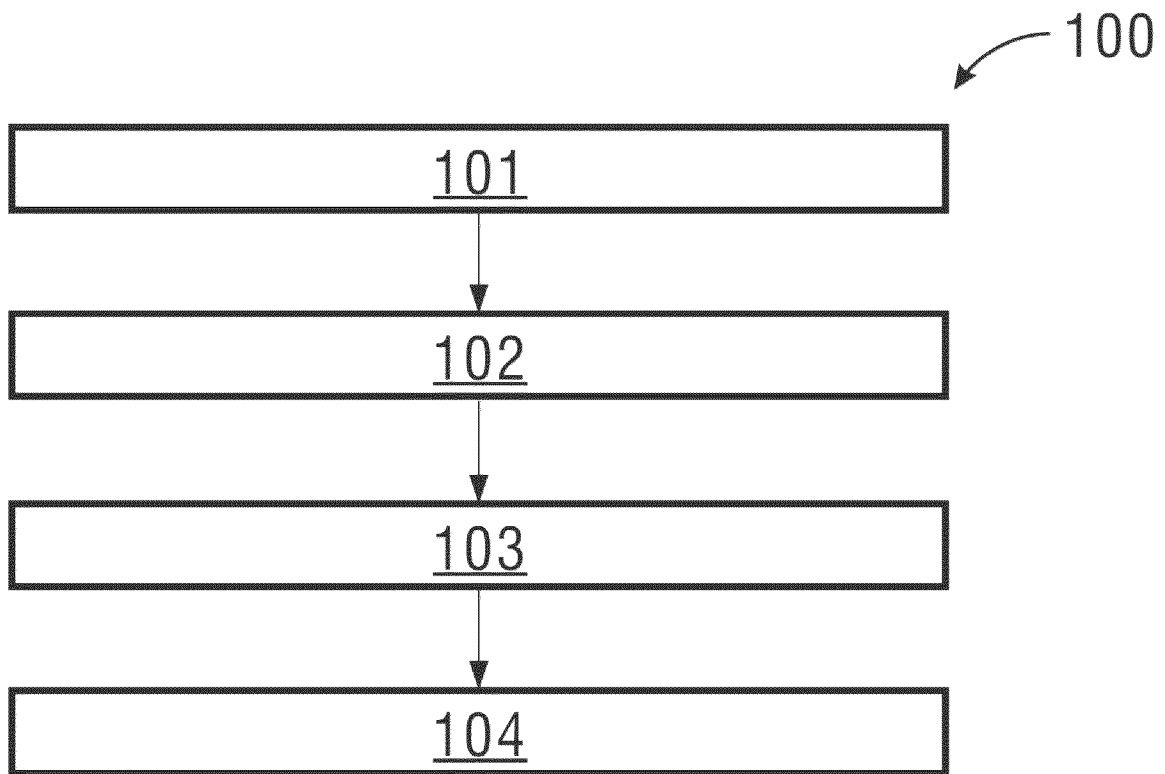
a second drive unit (404), for adjusting the first output voltage according to the first reactive current value and the reactive current mean value to obtain a second output voltage, and using the second output voltage to drive the permanent magnet synchronous motor to operate.

9. An electronic device (500), comprising: a processor (502), a communication interface (504), a memory (506) and a communication bus (508), the processor (502), the memory (506) and the communication interface (504) communicating with each other via the communication bus (508);

the memory (506) being configured to store at least one executable instruction, the executable instruction causing the processor (502) to perform an operation corresponding to the motor control method (100) as claimed in any one of claims 1 - 7.

10. A computer-readable storage medium, wherein the computer-readable storage medium has stored thereon a computer instruction which, when executed by a processor, causes the processor to perform the method as claimed in any one of claims 1 - 7.

11. A computer program product, wherein the computer program product is tangibly stored on a computer-readable medium and comprises a computer-executable instruction which, when executed, causes at least one processor to perform the method as claimed in any one of claims 1 - 7.

Drawings of the Description**Fig. 1**

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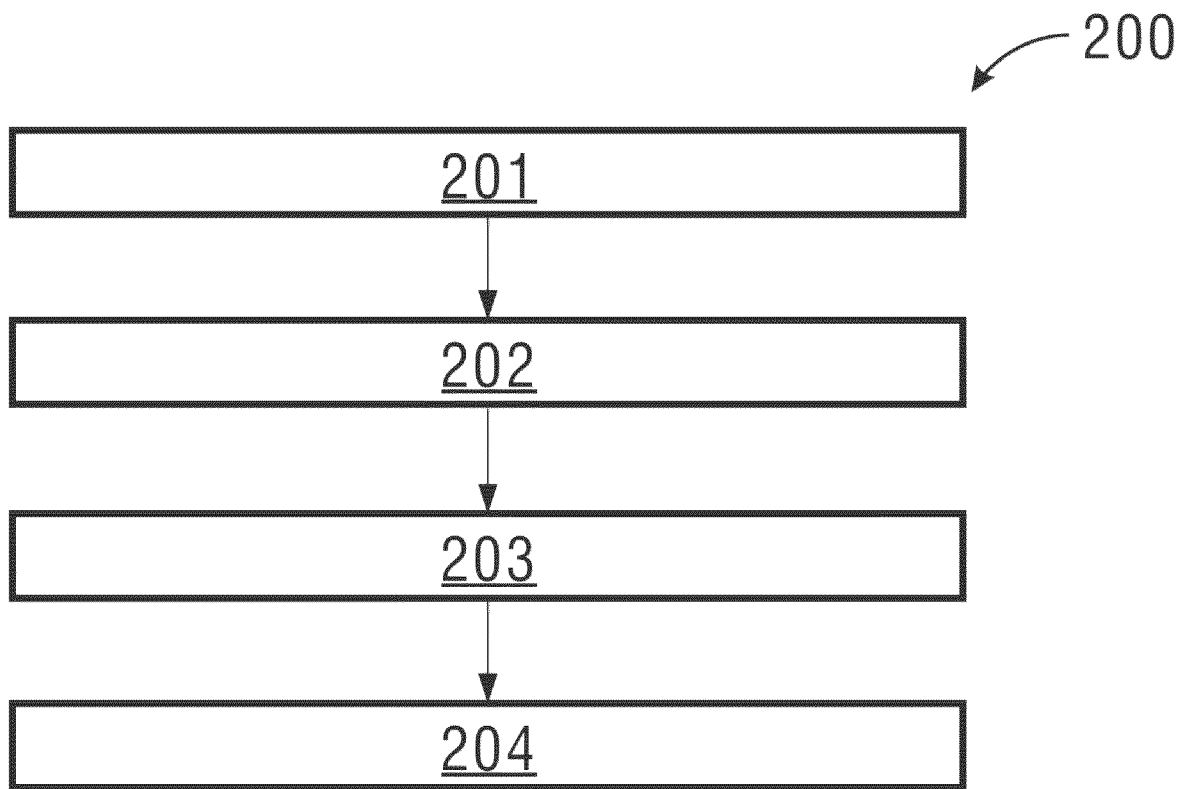


Fig. 2

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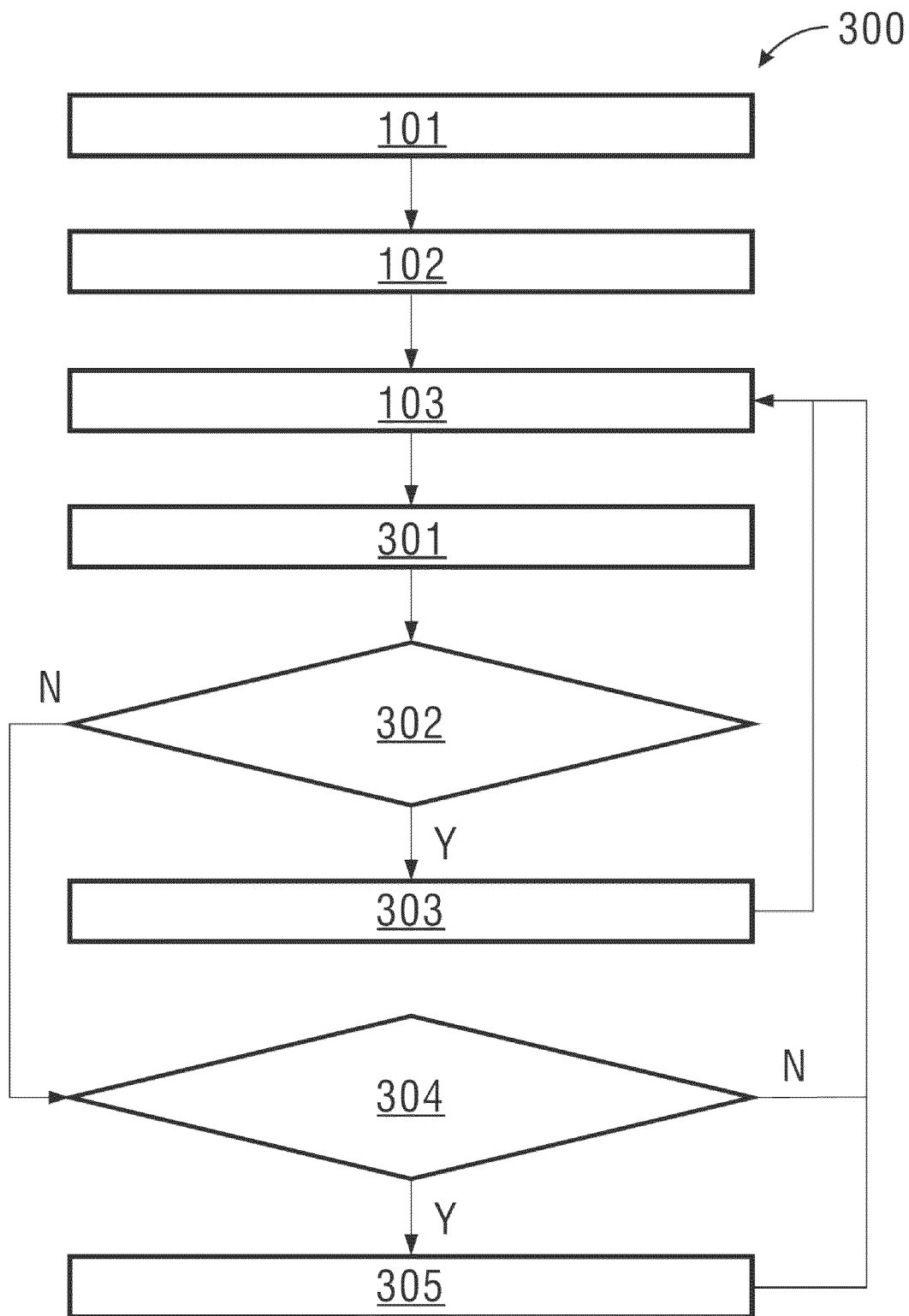


Fig. 3

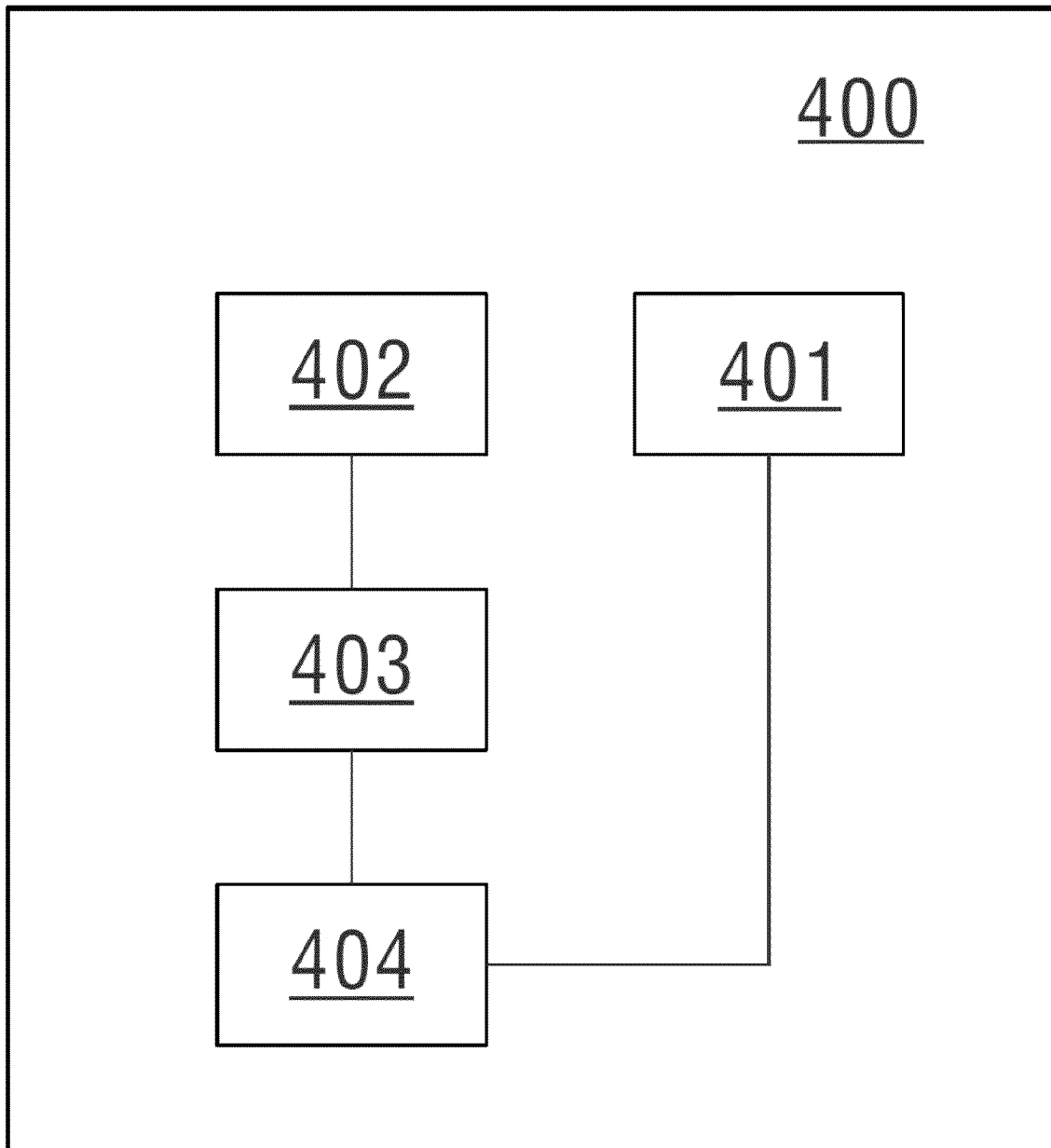


Fig. 4

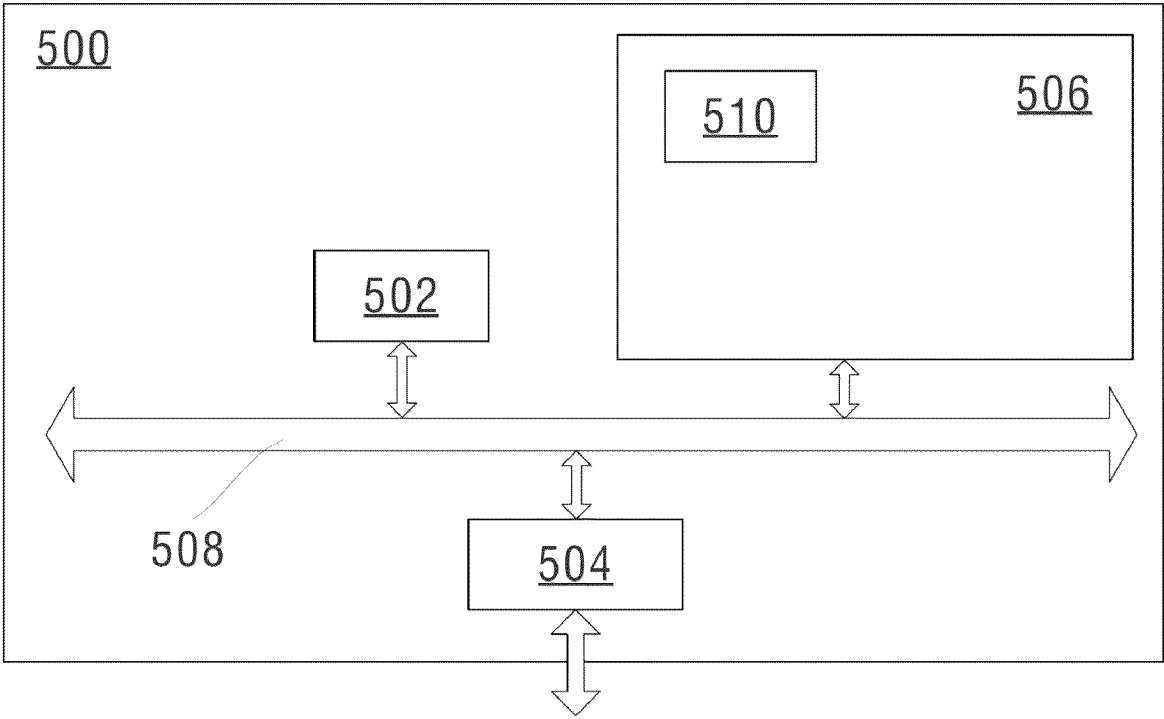


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/065389

A. CLASSIFICATION OF SUBJECT MATTER INV. H02P6/00 H02P23/14 H02P25/024 H02P29/032 ADD.		
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) H02P 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) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 115 765 570 A (DAYU ELECTRIC POLYTRON TECH CO LTD) 7 March 2023 (2023-03-07) the whole document -----	1 - 11
X	CN 114 710 069 A (SHANDONG KAIXINDE ELECTRONIC TECH CO LTD) 5 July 2022 (2022-07-05) the whole document -----	1 - 11
A	JP 2008 086098 A (FUJI ELEC FA COMPONENTS & SYS) 10 April 2008 (2008-04-10) the whole document -----	1 - 11
A	US 7 170 256 B2 (FANUC LTD [JP]) 30 January 2007 (2007-01-30) the whole document -----	1 - 11
☐ 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 29 August 2024		Date of mailing of the international search report 11/09/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Fraïssé, Stéphane

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/065389

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