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CONTROL DEVICE

Abstract

In a control device mounted on a vehicle provided with a traction motor, and including a processing unit and a storage unit, the processing unit sets a stored value stored in the storage unit to a predetermined parameter related to the drive control of the motor when reaching the first predetermined timing, and executes the estimation processing for this time for the estimated value related to the predetermined parameter using the stored value as an initial value, and when reaching the second predetermined timing, stores the estimated value in the estimation processing for this time as a stored value in the storage unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-019710 filed on Feb. 13, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a control device.

2. Description of Related Art

[0003] Conventionally, a control device that generates a voltage command value by a current control unit, from a current command value and a detected current value from a current sensor, has been proposed. The control device inputs the voltage command value to a plant model unit to calculate a virtual current value. The control device calculates a compensation value by inputting the virtual current value to a periodic disturbance observer via a coordinate transformation unit. The control device corrects the detected current value of the current sensor by superimposing the compensation value that is calculated on the detected current value via a coordinate inverse transformation unit (e.g., see Japanese Unexamined Patent Application Publication No. 2015-69439 (JP 2015-69439 A)). In this control device, offset error and gain error are calculated by inputting a value obtained by superimposing the detected current value and the compensation value, and the detected current value, to a current sensor error estimation unit, and error of the current sensor is estimated based on the error signals that are calculated.

SUMMARY

[0004] In such a control device, when a portion of various types of parameters related to drive control of a motor is sequentially updated, in some control devices, stability of drive control of the motor may deteriorate due to updating the parameter to a value with great error or the like.

[0005] A main object of the control device of the present disclosure is to suppress deterioration in stability of drive control of a motor.

[0006] In order to achieve the above primary object, the control device of the present disclosure employs the following measures.

[0007] [1] A control device according to an aspect of the present disclosure is a control device installed in a vehicle equipped with a traction motor, the control device including a processing unit and a storage unit, in which the processing unit, [0008] upon reaching a first predetermined timing, sets a stored value that is stored in the storage unit to a predetermined parameter related to drive control of the motor, and also executes estimation processing for this time regarding an estimated value related to the predetermined parameter, using the stored value as an initial value, and [0009] upon reaching a second predetermined timing, the estimated value in the estimation processing for this time is stored in the storage unit as the stored value.

[0010] In the control device according to the present disclosure, when the first predetermined timing is reached, the processing unit sets the stored value stored in the storage unit to the predetermined parameter related to the drive control of the motor. The processing unit uses the stored value as the initial value to execute the estimation processing for this time for the estimated value related to the predetermined parameter. Also, when the second predetermined timing is reached, the processing unit causes the storage unit to store the estimated value in the estimation processing for this time as the stored value. Accordingly, the processing unit sets the stored value to the predetermined parameter each time the first predetermined timing is reached. That is to say, the processing unit holds the predetermined parameter from reaching the first predetermined timing for this time until reaching the first predetermined timing for the next time. Thus, the processing unit circumvents successive updating (frequent updating) of the predetermined parameter. This can

suppress deterioration in stability of drive control of the motor. Also, by executing the estimation processing for this time for the estimated value related to the predetermined parameter, using the stored value as the initial value, the time until the estimated value converges in the estimation processing for this time can be suppressed from being long.
[0011] Now, the predetermined parameter may be a parameter regarding which a steep change is assumed to be unlikely. Specifically, the predetermined parameter may be a parameter that is assumed to have a gradual change characteristic (a change characteristic in which a change rate, which is a change amount per unit time, is no greater than a predetermined change rate) at an interval between the first predetermined timing and the second predetermined timing, or at an interval between the first predetermined timing for this time and the first predetermined timing for the next time. The present inventors have, through diligent study, confirmed that, with respect to a parameter that is assumed to be unlikely to exhibit steep change, stability of drive control of the motor is readily deteriorated by successive updating. The estimation processing for the predetermined parameter may be processing in which convergence of the estimated value is prioritized in comparison with responsivity as to a vicinity of a true value, and specifically may be processing in which the responsivity as to the vicinity of the true value is low but the convergence of the estimated value is good.
[0012] [2] In the control device of the present disclosure (the control device according to [1] above), [0013] upon reaching the second predetermined timing, the processing unit may store the estimated value as the stored value in the storage unit when the estimated value in the estimation processing for this time is within an allowable range, and may not store the estimated value in the storage unit when the estimated value in the estimation processing for this time is outside the allowable range.
[0014] [3] In the control device of the present disclosure (the control device according to [1] or [2] above), [0015] the first predetermined timing may include at least one of a timing at which system booting of the vehicle is instructed, a timing at which the vehicle is stopped by a brake operation, and a timing at which a torque command used for drive control of the motor crosses a torque threshold, and [0016] the second predetermined timing may include at least one of a timing at which system shutdown of the vehicle is instructed, and a timing at which a predetermined time elapsed from the first predetermined timing.
[0017] [4] In the control device of the present disclosure (the control device according to any one of [1] to [3] described above), [0018] the predetermined parameter may be a correction value based on at least one of a gain error of a current sensor that detects a phase current of each phase of the motor, and an offset error of the current sensor.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0019] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:
[0020] FIG. **1** is a schematic configuration diagram of a battery electric vehicle **20** including a control device according to an embodiment;
[0021] FIG. **2** is a flow chart illustrating an exemplary process routine executed by CPU **51** of the electronic control unit **50**;
[0022] FIG. **3** is an explanatory diagram illustrating an exemplary state of the correction value ΔId and the correction estimated value ΔIdc; and
[0023] FIG. **4** is a flowchart illustrating an example of a processing routine according to a modification.

DETAILED DESCRIPTION OF EMBODIMENTS

[0024] Embodiments for carrying out the present disclosure will be described with reference to the drawings. FIG. **1** is a schematic configuration diagram of a battery electric vehicle **20** including a control device according to an embodiment of the present disclosure. As illustrated, battery electric vehicle **20** of the embodiment includes a motor **32**, an inverter **34**, a battery **36** as a power storage device, and an electronic control unit **50** as a control device.

[0025] The motor **32** is configured as a three-phase AC motor, and includes a rotor in which a permanent magnet is embedded in a rotor core, and a stator in which a three-phase coil is wound around the stator core. The rotor of the motor **32** is connected to a drive shaft **26** connected to the drive wheels **22***a*, **22***b* via a differential gear **24**.

[0026] The inverter **34** is used to drive the motor **32** and is connected to the battery **36** via a power line **38**. The inverter **34** includes transistors T**11**-T**16** as six switching elements and six diodes D**11**-D**16** connected in parallel to the six transistors T**11**-T**16**. Transistors T**11**-T**16** are arranged in pairs of two so as to be source side and sink side with respect to the positive line and negative line of the power line **38**, respectively. Each of the connecting points of the transistors as paired transistors T**11**-T**16** is connected to each of the three-phase (U-phase, V-phase, W-phase) coils of the motor **32**. Thus, the electronic control unit **50** adjusts the rate of on-time of the paired transistors T**11**-T**16** when the inverter **34** is energized. Thus, a rotating magnetic field is formed in the three-phase coil of the motor **32**. The motor **32** (rotor) is rotationally driven.

[0027] The battery **36** is configured as, for example, a lithium-ion secondary battery or a nickel-hydrogen secondary battery, and is connected to the inverter **34** via the power line **38** as described above. A smoothing capacitor **39** is attached to the positive electrode line and the negative electrode line of the power line **38**.

[0028] The electronic control unit **50** includes a microcomputer having a CPU **51**, ROM **52**, RAM **53**, a flash memory **54**, an input/output port, and a communication port. The electronic control unit **50** receives signals from various sensors via input ports. For example, the electronic control unit **50** receives the rotational position θm from the rotational position sensor **32***a* that detects the rotational position of the rotor of the motor **32**, the phase currents Iu, Iv, Iw from the current sensors **32***u*, **32***v*, **32***w* that detects the phase current of each phase of the motor **32**, and the temperature am from the temperature sensor **32***t* that detects the temperature of the motor **32**. The electronic control unit **50** also receives a voltage Vb from a voltage sensor **36***v* mounted between terminals of the battery **36**, a current Ib from a current sensor **36***i* mounted to an output terminal of the battery **36**, a temperature at from a temperature sensor **36***t* mounted to the battery **36**, and a voltage VH of a capacitor **39** (power line **38**) from a voltage sensor **39***a* mounted between terminals of the capacitor **39**. The electronic control unit **50** also receives an on-off signal from the power switch **60**, a shift position SP from the shift sensor **62** for detecting the operation position of the shift lever **61**, an accelerator operation amount Acc from the accelerator pedal position sensor **64** for detecting the depression amount of the accelerator pedal **63**, a brake pedal position BP from the brake pedal position sensor **66** for detecting the depression amount of the brake pedal **65**, and a vehicle speed V from the vehicle speed sensor **67**.

[0029] The electronic control unit **50** outputs various control signals via an output port. For example, the electronic control unit **50** outputs a control signal to the transistors T**11**-T**16** of the inverter **34**. The electronic control unit **50** calculates the electric angle θe and the rotational speed Nm of the motor **32** based on the rotational position θm of the rotor of the motor **32** from the rotational position sensor **32***a*. The electronic control unit **50** calculates the power storage ratio SOC of the battery **36** based on the integrated value of the current Ib of the battery **36** from the current sensor **36***i*.

[0030] In battery electric vehicle **20** of the embodiment thus configured, the electronic control unit **50** (CPU **51**) sets the required torque Td* required for the drive shaft **26** based on the accelerator operation amount Acc and the vehicle speed V. The electronic control unit **50** sets the set required torque Td* to the torque command Tm* of the motor **32** so as to be outputted to the drive shaft **26**. The electronic control unit **50** performs switching control of the transistors T**11**-T**16** of the inverter **34** so that the motor **32** is driven by the torque command Tm *.

[0031] The electronic control unit **50** basically controls the inverter **34** by pulse-width-modulation (PWM) control. In PWM control, the electronic control unit **50** first performs coordinate conversion (three-phase-two-phase conversion) on the phase currents Iu, Iv, Iw of each phase of the motor **32** from the current sensors **32***u*, **32***v*, **32***w* using the electric angle θe based on the rotational position θm of the rotor of the motor **32** from the rotational position sensor **32***a*. Thus, the electronic control unit **50** calculates the current Id,Iq of the d-axis and the q-axis. Subsequently, the sensor error correction using the correction values ΔId and ΔIq is performed on the current Id,Iq of the d-axis and the q-axis to calculate the corrected currents Idco, Iqco of the d-axis and the q-axis. The correction values ΔId and ΔIq are parameters for correcting the current Id,Iq of the d-axis and the q-axis based on the sensor error (offset error or gain error) of the current sensors **32***u*, **32***v*, **32***w*. The correction values ΔId and ΔIq are part of various parameters related to the drive control of the motor **32**. Details of the correction values ΔId and ΔIq will be described later. Then, the current commands Id*, Iq* of the d-axis and the q-axis are set based on the torque command Tm* of the motor **32**. In addition, the electronic control unit **50** calculates the voltage commands Vd*, Vq* of the d-axis and the q-axis by the current feedback control so that the difference between the corrected currents Idco, Iqco of the d-axis and the q-axis and the current commands Id*, Iq * is canceled out. The electronic control unit **50** performs coordinate conversion (two-phase-three-phase conversion) of the calculated d-axis and q-axis voltage commands Vd*, Vq* using the electric angle de of the motor **32**. Thus, the electronic control unit **50** calculates the phase-voltage commands Vu*, Vv*, Vw of respective phases. The phase-voltage commands Vu*, Vv*, Vw of respective phases thus obtained are compared with a carrier wave (triangular wave) to generate a PWM signal of transistors T**11**-T**16**, and switching control of the transistors T**11**-T**16** is performed using the generated PWM signal.

[0032] Here, details of the correction values ΔId and ΔIq will be described. FIG. **2** is a flow chart showing an exemplary process routine executed by CPU **51** of the electronic control unit **50**. The execution of this routine is started when the first predetermined timing is reached. Here, as the first predetermined timing, a timing at which the power switch **60** is turned on (a timing at which a system start of the vehicle is instructed) is used.

[0033] When the process of FIG. **2** is executed, CPU **51** first sets the stored values ΔIdm and ΔIqm stored in the flash memory **54** to the correction value ΔId and ΔIq (S**100**). Here, the stored values ΔIdm and ΔIqm are set to nominal values (designed values) ΔId0 and ΔIq0, which are determined in advance immediately after the manufacturing of the vehicles, and are then updated by a process of S**140** described later. As described above, the correction values ΔId and ΔIq are used for drive control of the motor **32**. Specifically, the correction values ΔId and ΔIq are used for calculating the corrected currents Idco, Iqco of the d-axis and the q-axis by performing the sensor error correction using the correction values ΔId and ΔIq with respect to the current Id,Iq of the d-axis and the q-axis.

[0034] Subsequently, CPU **51** sets the stored values ΔIdm and ΔIqm to the initial values ΔIdi and ΔIqi (S**110**). CPU **51** performs the estimation processing for this time for the correction estimated values ΔIdc and ΔIqc related to the correction values ΔId and ΔIq using the set initial values ΔIdi and ΔIqi (S**120**). Here, as the estimation processing for the correction estimated value ΔIdc and ΔIqc, for example, regression analysis, smoothing processing, and the like can be exemplified. Examples of the regression analysis include a least squares method, a nonlinear least squares method, and the like. Examples of the smoothing process include a Kalman filter. Since the specific calculation methods of the correction estimated value ΔIdc and ΔIqc are well known, detailed description thereof will be omitted.

[0035] Then, CPU **51** determines whether or not the second predetermined timing has been reached

(S**130**), and returns to S**120** when it is determined that the second predetermined timing has not been reached. Here, as the second predetermined timing, a timing at which the power switch **60** is turned off (a timing at which a system stop of the vehicle is instructed) is used. When it is determined that the second predetermined timing has been reached by S**130**, CPU **51** stores the corrected estimated values ΔIdc and ΔIqc at that time as the stored values ΔIdm and ΔIqm in the flash memory **54**. Accordingly, CPU **51** updates the stored values ΔIdm and ΔIqm (S**140**). CPU **51** terminates the routine.

[0036] Here, a sensor error (an offset error or a gain error) of the current sensors **32***u*, **32***v*, **32***w* depends on a manufacturing variation of the current sensors **32***u*, **32***v*, **32***w*, a secular change, and the like. It is assumed that a steep change is unlikely to occur, specifically, at an interval between the first predetermined timing and the second predetermined timing, and at an interval between the previous first predetermined timing and the first predetermined timing for this time, a gradual change characteristic (a change characteristic in which a change rate, which is a change amount per unit time, is equal to or less than a predetermined change rate) is provided. Therefore, the correction values ΔId and ΔIq based on the sensor error of the current sensors **32***u*, **32***v*, **32***w* are parameters that are assumed to be less likely to cause a steep change. Therefore, when the correction values ΔId and ΔIq are sequentially updated (frequently updated), there is a possibility that, for example, the correction values ΔId and ΔIq are updated to a value having a large error, and consequently, the stability of the drive control of the motor **32** is deteriorated. In contrast, in the embodiment, the correction values ΔId and ΔIq are updated every time the first predetermined timing is reached. That is, the correction values ΔId and ΔIq are held from the current first predetermined timing for this time to the next first predetermined timing. Accordingly, it is possible to suppress a decrease in the stability of the drive control of the motor **32**. In addition, the estimation processing this time for this time for the correction estimated values ΔIdc and ΔIqc is performed by using the stored values ΔIdm and ΔIqm as the initial values ΔIdi and ΔIqi. As a result, it is possible to suppress the time required for the correction estimated values ΔIdc and ΔIqc to converge in the estimation processing for this time from becoming longer.

[0037] FIG. **3** is an explanatory diagram illustrating an example of the state of the correction value ΔId and the correction estimated value ΔIdc. Although not illustrated, the correction value ΔIq and the correction estimated value ΔIqc can also be considered in the same manner as the correction value ΔId and the correction estimated value ΔIdc. In the drawing, the times t**11**, t**13**, t**15** is a first predetermined timing (a timing at which the system start of the vehicle is instructed), and the times t**12**, t**14** are a second predetermined timing (a timing at which the system stop of the vehicle is instructed). That is, the times t**11**-t**12**, t**13**-t**14**, t**15**—correspond to the respective trips. As shown in the figure, when the first predetermined timing is reached (times t**11**, t**13**, t**15**), the stored values ΔIdm and ΔIqm are set to the correction values ΔId and ΔIq. The estimation processing for the correction estimated values ΔIdc and ΔIqc is executed using the stored values ΔIdm and ΔIqm as the initial values ΔIdi and ΔIqi. After that, when the second predetermined timing is reached (times t**12**, t**14**), the corrected estimated values ΔIdc and ΔIqc are set to the stored values ΔIdm and ΔIqm, and the stored values ΔIdm and ΔIqm are updated. During the estimation processing for the correction estimated values ΔIdc and ΔIqc, the correction estimated values ΔIdc and ΔIqc may vary relatively greatly. Therefore, when the correction values ΔId and ΔIq are sequentially updated by using the correction estimated values ΔIdc and ΔIqc, there is a possibility that the correction values ΔId and ΔIq suddenly change. This leads to a decrease in the stability of the drive control of the motor **32**. On the other hand, in the embodiment, by holding the correction values ΔId and ΔIq from the first predetermined timing for this time to the first predetermined timing of the next time, successive updating (frequent updating) of the correction values ΔId and ΔIq is avoided. This suppresses a decrease in stability of the drive control of the motor **32**. In the estimation processing for this time for the correction estimated values ΔIdc and ΔIqc, the stored values ΔIdm and ΔIqm in which the correction estimated values (previous ΔIdc) and (previous ΔIqc) in the previous estimation processing are set are used as the initial values ΔIdi and ΔIqi. As a result, it is possible to suppress the time required for the correction estimated values ΔIde and ΔIqc to converge in the estimation processing for this time from becoming longer than when the nominal values ΔId0 and ΔIq0 are used as the initial values ΔIdi and ΔIqi each time.

[0038] In the electronic control unit **50** mounted on battery electric vehicle **20** of the present embodiment described above, CPU **51** sets the stored values ΔIdm and ΔIqm to the correction values ΔId and ΔIq when the first predetermined timing is reached. CPU **51** performs an estimation processing for the corrected estimated values ΔIdc and ΔIqc by using the stored values ΔIdm and ΔIqm as the initial values ΔIdi and ΔIqi. After that, when the second predetermined timing is reached, the stored values ΔIdm and ΔIqm are updated by storing the correction estimated values ΔIdc and ΔIqc as the stored values ΔIdm and ΔIqm in the flash memory **54**. As a result, it is possible to avoid the sequential updating (frequent updating) of the correction values ΔId and ΔIq, and to suppress a decrease in the stability of the drive control of the motor **32**. In addition, it is possible to suppress the time required for the correction estimated values ΔIdc and ΔIqc to converge in the estimation processing from becoming longer.

[0039] In the above-described embodiment, CPU **51** stores the corrected estimated values ΔIdc and ΔIqc as the stored values ΔIdm and ΔIqm in the flash memory **54** when the second predetermined timing is reached, as illustrated in the process routine of FIG. **2**. Accordingly, CPU **51** updates the stored values ΔIdm and ΔIqm. Without limitation For example, CPU **51** may execute the processing routine of FIG. **4** instead of the processing routine of FIG. **2**. The processing routine of FIG. **4** differs from the processing routine of FIG. **2** in that S**132** processing is added. In the processing routine of FIG. **4**, when it is determined that S**130** reaches the second predetermined timing, it is determined whether the corrected estimated values ΔIdc and ΔIqc in the estimation processing for this time are within the allowable range (S**132**). Here, as the allowable range, for example, a range that can be normally taken, a range of a predetermined change amount with respect to correction estimated values (previous ΔIdc) and (previous ΔIqc) in the previous estimation processing, and the like can be used. When it is determined that the correction estimated values ΔIdc and ΔIqc in the estimation processing for this time are within the allowable range, the correction estimated values ΔIdc and ΔIqc are stored as the stored values ΔIdm and ΔIqm in the flash memory **54** (S**140**), and the routine ends. On the other hand, when it is determined that the correction estimated values ΔIdc and ΔIqc in the estimation processing for this time are outside the allowable range, the present routine is ended without storing the correction estimated values ΔIdc and ΔIqc as the stored values ΔIdm and ΔIqm in the flash memory **54**. As a result, it is possible to avoid setting an abnormal value to the stored values ΔIdm and ΔIqm.

[0040] In the above-described embodiment, CPU **51** uses, as the first predetermined timing, a timing at which the power switch **60** is turned on (a timing at which a system start of the vehicle is instructed). CPU **51** uses, as the second predetermined timing, a timing at which the power switch **60** is turned off (a timing at which a system-stop of the vehicle is instructed). Without being limited thereto. For example, CPU **51** may use, as the first predetermined timing, a timing at which the vehicle is stopped by operating the brake pedal **65** and/or a timing at which the torque command Tm * of the motor **32** crosses the threshold Tmref in addition to or in place of the timing at which the system activation of the vehicle is instructed. As the second predetermined timing, a timing at which a predetermined time has elapsed from the first predetermined timing (for example, about several minutes to several tens of minutes) may be used in addition to or instead of the timing at which the system stop of the vehicle is instructed.

[0041] In the above-described embodiment, the correction values ΔId and ΔIq are correction values based on the sensor error (offset error or gain error) of the current sensors **32***u*, **32***v*, **32***w*, but the present disclosure is not limited thereto. For example, the correction values ΔId and ΔIq may be correction values based on only one of the offset error and the gain error of the current sensors **32***u*, **32***v*, **32***w*, or may be correction values based on the sensor error of the rotational position sensor

32a.

[0042] In the above-described embodiment, the battery **36** is used as the power storage device, but the present disclosure is not limited thereto. For example, a capacitor may be used as the power storage device.

[0043] In the above-described embodiment, the electronic control unit **50** as the control device is mounted on a battery electric vehicle **20** including the traction motor **32** and the inverter **34** that drives the traction motor. For example, the control device may be mounted on a hybrid electric vehicle that further includes an engine in addition to a hardware configuration similar to that of battery electric vehicle **20**. The control device may be mounted on a fuel cell electric vehicle that further includes a fuel-cell in addition to a hardware configuration similar to battery electric vehicle **20**.

[0044] The correspondence between the main elements of the embodiments and the main elements of the disclosure described in the column of the means for solving the problem will be described. In the embodiment, CPU **51** corresponds to the “processing unit” and the flash memory **54** corresponds to the “storage unit”.

[0045] The correspondence between the main elements of the embodiment and the main elements of the disclosure described in the section of the means for solving the problem is an example for specifically explaining the embodiment of the disclosure described in the section of the means for solving the problem. It is not intended to limit the elements of the disclosure described in the Means for Solving the Problem section. That is, the interpretation of the disclosure described in the section of the means for solving the problem should be performed based on the description in the section, and the embodiments are only specific examples of the disclosure described in the section of the means for solving the problem.

[0046] Although the embodiments for carrying out the present disclosure have been described using the embodiments, it is needless to say that the present disclosure is not limited to such embodiments, and can be implemented in various forms without departing from the gist of the present disclosure.

[0047] The present disclosure is applicable to a manufacturing industry of a control device and the like.

Claims

1. A control device installed in a vehicle equipped with a traction motor, the control device comprising: a processing unit; and a storage unit, wherein the processing unit, upon reaching a first predetermined timing, sets a stored value that is stored in the storage unit to a predetermined parameter related to drive control of the motor, and also executes estimation processing for this time regarding an estimated value related to the predetermined parameter, using the stored value as an initial value, and upon reaching a second predetermined timing, the estimated value in the estimation processing for this time is stored in the storage unit as the stored value.

2. The control device according to claim 1, wherein upon reaching the second predetermined timing, the processing unit stores the estimated value as the stored value in the storage unit when the estimated value in the estimation processing for this time is within an allowable range, and does not store the estimated value in the storage unit when the estimated value in the estimation processing for this time is outside the allowable range.

3. The control device according to claim 1, wherein: the first predetermined timing includes at least one of a timing at which system booting of the vehicle is instructed, a timing at which the vehicle is stopped by a brake operation, and a timing at which a torque command used for drive control of the motor crosses a torque threshold; and the second predetermined timing includes at least one of a timing at which system shutdown of the vehicle is instructed, and a timing at which a predetermined time elapsed from the first predetermined timing.

4. The control device according to claim 1, wherein the predetermined parameter is a correction value based on at least one of a gain error of a current sensor that detects a phase current of each phase of the motor, and an offset error of the current sensor.