United States Patent Application Publication	20250263117
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	Pelludat; Sebastian et al.

Steering Device and Method for Operating the Steering Device

Abstract

A steering device includes a steering rack, an electric motor for setting a position of the steering rack, a first control unit for controlling the electric motor depending on a deviation of an actual position of the steering rack from a target position of the steering rack, a second control unit for controlling the electric motor as a function of the deviation of the actual position from the target position, and a device for switching from control of the electric motor by the first control unit to control of the electric motor by the second control unit. The device is configured to switch from control of the electric motor by the first control unit to control of the electric motor by the second control unit as a function of a deviation of an actual value from a target value.

Inventors: **Pelludat; Sebastian (Schorndorf, DE), Mueller; Claus-Dieter (Waldstetten, DE), Erdmann; Dominik (Stuttgart, DE), Rot; Edgar (Moeglingen, DE), Jochim; Hannes (Kirchberg And Der Murr, DE), Govindarajulu; Hemanth Kumar (Bietigheim-Bissingen, DE), Niess; Marcel (Steinheim, DE), Eirich; Marian (Remseck, DE), Salaris; Marianna (Pleidelsheim, DE)**

Applicant: **Robert Bosch GmbH** (Stuttgart, DE)

Family ID: **1000008448654**

Appl. No.: **19/046213**

Filed: **February 05, 2025**

Foreign Application Priority Data

DE	10 2024 201 383.8	Feb. 15, 2024

Publication Classification

Int. Cl.: **B62D5/04** (20060101)

U.S. Cl.:

CPC **B62D5/049** (20130101); **B62D5/046** (20130101);

Background/Summary

[0001] This application claims priority under 35 U.S.C. § 119 to patent application no. DE 10 2024 201 383.8, filed on Feb. 15, 2024 in Germany, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The disclosure relates to a steering device and a method for operating the steering device.

SUMMARY

[0003] Steering device failure is prevented by means of the steering device and method according to this disclosure. Increased requirements for control unit accuracy and/or requirements pursuant to ASIL D are met as a result.

[0004] The steering device comprises a steering rack, an electric motor for setting a position of the steering rack, a first control unit for controlling the electric motor depending on a deviation of an actual position of the steering rack from a target position of the steering rack, a second control unit for controlling the electric motor as a function of the deviation of the target position from the actual position, and a device for switching from control of the electric motor by the first control unit to control of the electric motor by the second control unit, wherein the device is configured to switch from control of the electric motor by the first control unit to control of the electric motor by the second control unit as a function of a deviation of an actual value from a target value, wherein the actual value is the actual position of the steering rack and the target value is the target position of the steering rack, or wherein the actual value is a derivative of an actual position of the steering rack and the target value is determined based on a difference between the actual position and a target position of the steering rack.

[0005] The device may be configured to monitor the deviation of the actual value from the target value and to switch from control of the electric motor by the first control unit to control of the electric motor by the second control unit, depending on the deviation of the actual value from the target value.

[0006] The device may be configured to compare the deviation of the actual value from the target value to a threshold value and to switch from control of the electric motor by the first control unit to control of the electric motor by the second control unit if the deviation of the actual value from the target value is greater than the threshold value. This means that the device is configured to recognize a necessity for switching particularly well.

[0007] The device may be configured to determine the threshold value depending on the deviation of the actual value from the target value. This means that the device is configured to adjust the threshold value to the deviation of the actual value from the target value.

[0008] The device may be configured to determine an increasingly narrow threshold value with increasing deviation of the actual value from the target value. This means that the device is configured to more sensitively adjust the threshold value as the actual value deviates from the target value.

[0009] The device may be configured to determine the threshold value for a positive deviation of the actual value from the target value as well as the threshold value for a negative deviation of the actual value from the target value. The threshold values may be the same or may be different from one another. This means that the device is configured to set asymmetrical threshold values.

[0010] A vehicle may be provided comprising the steering device.

[0011] The method for operating a steering device provides for a steering device comprising a steering rack, an electric motor for setting a position of the steering rack, a first control unit for

controlling the electric motor depending on a deviation of an actual position of the steering rack from a target position of the steering rack, a second control unit for controlling the electric motor as a function of the deviation of the actual position from the target position of the steering rack, wherein it is switched from control of the electric motor by the first control unit to control of the electric motor by the second control unit as a function of a deviation of an actual value from a target value, wherein the actual value is the actual position of the steering rack and the target value is the target position of the steering rack, or wherein the actual value is a derivative of an actual position of the steering rack and the target value is determined based on a difference between the actual position and a target position of the steering rack.

[0012] The method may provide for monitoring of the deviation of the actual value from the target value and switching from control of the electric motor by the first control unit to control of the electric motor by the second control unit, depending on the deviation of the actual value from the target value. The necessity of switching is thus particularly well recognized.

[0013] The method may provide for comparing the deviation of the actual value from the target value to a threshold value and switching from control of the electric motor by the first control unit to control of the electric motor by the second control unit if the deviation of the actual value from the target value is greater than the threshold value.

[0014] The method may provide for determining the threshold value based on the deviation of the actual value from the target value. The threshold value is thus adjusted to the deviation of the actual value from the target value.

[0015] The method may provide for determining an increasingly narrow threshold value based on the deviation of the actual value from the target value. This means that the threshold value is more sensitively adjusted with increasing deviation of the actual value from the target value.

[0016] The method may provide for determining the threshold value for a positive deviation of the actual value from the target value as well as the threshold value for a negative deviation of the actual value from the target value. The threshold values may be the same or may be different from one another. This sets asymmetric threshold values.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Further advantageous embodiments will become apparent from the following description and the drawing. The drawings show:

[0018] FIG. **1** a schematic representation of a vehicle with a steering system,

[0019] FIG. **2** an exemplary first control unit of the steering device,

[0020] FIG. **3** an exemplary second control unit of the steering device, and

[0021] FIG. **4** a flow chart showing the steps of a method for operating the steering system.

DETAILED DESCRIPTION

[0022] A vehicle **100** having a steering system **102** is schematically illustrated in FIG. **1**. The steering device **104** is configured to steer guided wheels **104** of the vehicle **100**.

[0023] The steering device **102** comprises a steering rack **106** configured to steer the guided wheels **104**.

[0024] The steering device **102** comprises an electric motor **108** for adjusting a position of the steering rack **106**.

[0025] The steering device **102** comprises a first control unit **110** for controlling the electric motor **108**. The steering device **102** includes a second control unit **112** for controlling the electric motor **108**. The steering device **102** includes a device **114** for switching from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112**.

[0026] The first control unit **110** is configured to control the electric motor **108** as a function of a

deviation **116** of an actual position **118** of the steering rack **106** from a target position **120** of the steering rack.
[0027] The second control unit **112** is configured to control the electric motor **108** as a function of a deviation **116** of the actual position **118** of the steering rack **106** from the target position **120** of the steering rack **106**.
[0028] The device **114** is configured to switch from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112**, depending on a deviation **116′** of an actual value from a target value.
[0029] In one example, the actual value is the actual position **118** of steering rack **106** and the target value is the target position **120** of steering rack **106**.
[0030] In one example, the actual value is a derivative of the actual position **118** of the steering rack **106** and the target value is determined based on a difference between the actual position **118** and the target position **120**.
[0031] In the example, the steering device **102** comprises a computing device **122** configured to determine the deviation **116** of the actual position **118** from the target position **120**.
[0032] In one example, the computing device **122** is configured to determine the deviation **116** of the actual position **118** from the target position **120** based on a difference between the actual position **118** and the target position **120**.
[0033] In one example, the computing device **122** is configured to determine the deviation **116′** of the actual value from the target value.
[0034] In one example, the actual value is the actual position **118** of steering rack **106** and the target value is the target position **120** of steering rack **106**.
[0035] In one example, the actual value is a derivative of the actual position **118** of the steering rack **106** and the target value is determined based on a difference between the actual position and a target position **120** of the steering rack **106**.
[0036] The device **114** is configured to monitor the deviation **116′** of the actual value from the target value and to switch from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112**, depending on the deviation **116′**.
[0037] In the example, the device **114** comprises a switch **124** configured to switch from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112** based on a switch signal **126**.
[0038] In the example, the device **114** comprises a monitoring device **128** configured to monitor the deviation **116′** of the actual value from the target value and determine the switching signal **126** to switch from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112** based on the deviation **116**.
[0039] The device **114**, in the example the monitoring device **128**, may be configured to compare the deviation **116′** of the actual value from the target value to a threshold value and to switch from control of the electric motor **108** by the first control unit **110** to control of the electric motor **108** by the second control unit **112** if the deviation **116′** of the actual value from the target value is greater than the threshold value.
[0040] The device **114**, in the example the monitoring device **128**, may provide for determining the threshold value based on the deviation **116′** of the actual value from the target value.
[0041] The device **114**, in the example the monitoring device **128**, may provide for determining the threshold value based on the difference determined by the computing device **122** between the actual position **118** and the target position **120**.
[0042] The device **114**, in the example the monitoring device **128**, may provide for determining an increasingly narrow threshold value with increasing deviation **116′** of the actual value from the target value.
[0043] The device **114**, in the example the monitoring device **128**, may be configured to determine, for the deviation **116′** of the actual value from the target value, both the threshold value for a

positive deviation **116**′ of the actual value from the target value as well as the threshold value for a negative deviation **116**′ of the actual value from the target value.
[0044] For example, the threshold value for the positive deviation **116**′ of the actual value from the target value may differ from the threshold value for the negative deviation **116**′ of the actual value from the target value. In the example, the threshold values are provided such that a speed of the steering rack **106** is within an accepted range as long as the deviation **116**′ of the actual value from the target value is within the threshold values. The threshold values are provided in the example such that the device **114** is configured to switch when the speed of the steering rack **106** leaves the accepted range.
[0045] In the example, the first control unit **110** is configured to determine a first target motor torque **130** based on the deviation **116** of the actual position **118** from the target position **120**, in order to control the electric motor **108**.
[0046] In the example, the second control unit **112** is configured to determine a second target motor torque **132** based on the deviation **116** of the actual position **118** from the target position **120**, in order to control the electric motor **108**.
[0047] In the example, the electric motor **108** is controlled by either the first target motor torque **130** or the second target motor torque **132**, depending on the position of the switch **124**.
[0048] An exemplary first control unit **110** is shown in FIG. **2**. For example, the first control unit **110** is configured to control the first target motor torque **130** with a first torque controller **206**, depending on a deviation **202** of the actual value **134** from a target value **204**. The first torque controller **206** in the example is a PID controller. The first control unit **110** and the second control unit **112** differ. The first control unit **110** and the second control unit **112** are preferably different such that the same error does result in faulty motor torque in both.
[0049] In the example, the first control unit **110** is configured to determine the target value **204** based on the deviation **116** of the actual position **118** from the target position **120**. In the example, the first controller **110** is configured to determine the target value **204** from a characteristic curve **208** that associates the deviation **116** with the target value **204**. It may be contemplated that the characteristic curve **208** is selected from a multitude **210** of characteristic curves depending on the deviation **116** of the actual position **118** from the target position **120**.
[0050] An exemplary second control unit **112** is shown in FIG. **3**. As an example, the second control unit **112** is configured to control the second target motor torque **132** with a second torque controller **302** depending on the deviation **116** of the actual position **118** from the target position **120**. The second torque controller **302** in the example is a PID controller.
[0051] FIG. **4** shows steps of a method for operating the steering device **102**.
[0052] The method comprises a step **402**.
[0053] In step **402**, the electric motor **108** is controlled by the first control unit **110** depending on the deviation **116** of the actual position **118** from the target position **120**.
[0054] The method comprises a step **404**.
[0055] In step **404**, it is determined whether or not to switch from control of the electric motor **108** by the first control unit **110** to control **408** of the electric motor **108** by the second control unit **112**.
[0056] If it is determined that the control of the electric motor **108** by the first control unit **110** should be switched to control **408** of the electric motor **108** by the second control unit **112**, the step **406** is performed. Otherwise, step **402** is performed.
[0057] For example, the deviation **116**′ of the actual value from the target value is monitored.
[0058] For example, the deviation **116**′ of the actual value from the target value is compared to a threshold value and it is determined that control of the electric motor **108** by the first control unit **110** should be switched to control **408** of the electric motor **108** by the second control unit **112** if the deviation **116**′ of the actual value from the target value is greater than the threshold value.
[0059] It may be provided that the threshold value is determined based on the deviation **116**′ of the actual value from the target value. It may be provided that an increasingly narrow threshold value

is determined with increasing deviation **116**′ of the actual value from the target value.
[0060] It may be provided that the threshold value is determined from the target position **120** of the steering rack **106** depending on the deviation **116** of the actual position **118** of the steering rack **106**. It may be provided that an increasingly narrow threshold value is determined with an increasing deviation **116** of the actual position **118** of the steering rack **106** from the target position **120** of the steering rack **106**.
[0061] In one example, it is provided that, for the deviation **116**′ of the actual value from the target value, both the threshold value for a positive deviation **116**′ of the actual value from the target value and a negative deviation **116**′ of the actual value from the target value are determined, whereby the threshold values differ from one another.
[0062] This means that asymmetric threshold values are used.
[0063] In the example, the threshold value is provided such that a speed of the steering rack **106** remains within an accepted range as long as the deviation **116**′ of the actual value from the target value is within the threshold values. That is, the switching occurs when the speed of the steering rack **106** leaves the accepted range.
[0064] In step **406**, control of the electric motor **108** by the first control unit **110** is switched to control **408** of the electric motor **108** by the second control unit **112**.
[0065] This means that the deviation **116**′ of the actual value from the target value may be monitored and the particularly increasingly narrow threshold value is determined based on the deviation **116**.
[0066] This means the deviation **116**′ of the actual value from the target value may be monitored and control of the electric motor **108** by the first control unit **110** may be switched to control of the electric motor **108** by the second control unit **112**, depending on the deviation **116**′ of the actual value from the target value.
[0067] This means that the deviation **116**′ of the actual value from the target value may be monitored and, if there is a positive deviation **116**′ of the actual value from the target value that is larger than the threshold value for the positive deviation, or if there is a negative deviation **116**′ of the actual value from the target value, the absolute value of which is larger than the threshold value for the negative deviation **116**′, the switching occurs.
[0068] Step **408** is then performed.
[0069] In step **408**, the electric motor **108** is controlled by the second control unit **112** based on the deviation **116** of the actual position **118** from the target position **120**.

Claims

1. A steering device, comprising: a steering rack; an electric motor configured to set a position of the steering rack; a first control unit configured to control the electric motor depending on a deviation of an actual position of the steering rack from a target position of the steering rack; a second control unit configured to control the electric motor as a function of the deviation of the actual position from the target position; and a device configured to switch from control of the electric motor by the first control unit to control of the electric motor by the second control unit as a function of a deviation of an actual value from a target value, wherein (i) the actual value is the actual position of the steering rack and the target value is the target position of the steering rack, or (ii) the actual value is a derivative of the actual position of the steering rack and the target value is determined based on a difference between the actual position and the target position of the steering rack.
2. The steering device according to claim 1, wherein the device is configured to monitor the deviation of the actual value from the target value and to switch from the control of the electric motor by the first control unit to the control of the electric motor by the second control unit, depending on the deviation of the actual value from the target value.

3. The steering device according to claim 2, wherein the device is configured to compare the deviation of the actual value from the target value to a threshold value, and to switch from the control of the electric motor by the first control unit to the control of the electric motor by the second control unit when the deviation of the actual value from the target value is greater than the threshold value.
4. The steering device according to claim 3, wherein the device is configured to determine the threshold value based on the deviation of the actual value from the target value.
5. The steering device according to claim 4, wherein the device is configured to determine an increasingly narrow threshold value with an increasing deviation of the actual value from the target value.
6. The steering device according to claim 3, wherein the device is configured to determine the threshold value for (i) the deviation of the actual value from the target value for a positive deviation, and (ii) the deviation of the actual value from the target value for a negative deviation.
7. A vehicle, comprising: the steering device according to claim 1.
8. A method for operating a steering device comprising a steering rack, the method comprising: setting a position of the steering rack using an electric motor; controlling the electric motor using a first control unit depending on a deviation of an actual position of the steering rack from a target position of the steering rack; controlling the electric motor using a second control unit as a function of the deviation of the actual position from the target position; and switching control of the electric motor by the first control unit to control of the electric motor by the second control unit as a function of a deviation of an actual value from a target value, wherein (i) the actual value is the actual position of the steering rack and the target value is the target position of the steering rack, or (ii) the actual value is a derivative of the actual position of the steering rack and the target value is determined based on a difference between the actual position and the target position of the steering rack.
9. The method according to claim 8, further comprising: monitoring the deviation of the actual value from the target value; and switching control of the electric motor by the first control unit to control of the electric motor by the second control unit depending on the monitored deviation of the actual value from the target value.
10. The method according to claim 9, further comprising: comparing the deviation of the actual value from the target value to a threshold value; and switching the control of the electric motor by first control unit to the control of the electric motor by the second control unit when the compared deviation of the actual value from the target value is greater than the threshold value.
11. The method according to claim 10, wherein the threshold value is determined based on the deviation of the actual value from the target value.
12. The method according to claim 11, wherein an increasingly narrow threshold value is determined with increasing deviation of the actual value from the target value.
13. The method according to claim 10, wherein, for the deviation of the actual value from the target value, both the threshold value for a positive deviation of the actual value from the target value and a negative deviation of the actual value from the target value, is determined.