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(71) Applicant(s)
Robert Bosch GmbH

(72) Inventor(s)
POWER, Michael;FRUEH, Philipp

(74) Agent / Attorney
Spruson & Ferguson, GPO Box 3898, Sydney, NSW, 2001, AU

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Summary

5 A trailer mounted brake controller (9) for controlling operation of brakes in a trailer (5) is presented. The trailer mounted brake controller (9) comprises a first signal interface (19) for receiving trailer status signals from sensors (15) in the trailer (5), the trailer status signals relating to a current driving status of the trailer (5);

10 a second signal interface (21) for receiving towing vehicle status signals from at least one of sensors and controllers in a towing vehicle (3) towing the trailer (5), the towing vehicle status signals relating to at least one of a current driving status of the towing vehicle (3) and an operation status of a towing vehicle mounted brake controller (7);

15 a third signal interface (23) for transmitting brake control signals to brakes of the trailer (5); and

a signal processor (27) being configured for generating the brake control signals taking into account both the trailer status signals and the towing vehicle status signals.

20 The trailer mounted brake controller (9) may be part of a brake controller system (31) in which a towing vehicle mounted brake controller (7) in the towing vehicle (3) and the trailer mounted brake controller (9) in the trailer (5) may exchange signals and data via a vehicle communication network (25). Accordingly, braking actions of the trailer (5) as well as of the towing vehicle (3) may be coordinated taking into account the current driving status of the respective other part of a

25 vehicle train (1)

30 (Fig. 1)

Description

Brake controller system comprising a trailer mounted brake controller and a towing vehicle mounted brake controller

Field of the invention

The present invention relates to a distributed brake controller system in a vehicle train comprising a towing vehicle and a connected trailer. Particularly, the present invention relates to a trailer mounted brake controller and to a towing vehicle mounted brake controller and the communication between them.

Background of the invention

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

A trailer is towed by a towing vehicle such as a car. Generally, a driver drives the car and the driver's intention to accelerate or decelerate the car directly or indirectly affects the trailer. For example, the trailer may comprise brakes which are actuated when the driver actuates the towing vehicle's brakes such that the towing vehicle is decelerated.

In some regions such as Europe, the brakes of the trailer are typically mechanically actuated by and coupled to the towing vehicle. In regions such as North America and Australia, an electric trailer brake controller is typically utilised in the towing vehicle and controls actuation of the brakes of the trailer. In such approach, the brakes of the trailer are typically electrically actuated brakes comprising for example a magnetic solenoid and the brakes of the trailer are activated upon receiving an electric activation signal from the trailer brake controller. In North America and Australia, there are also so called electric over hydraulic brake actuators on the trailer. The electric brake signal goes to the electric over hydraulic brake actuator. The brake actuator creates a hydraulic pressure proportional to the electric signal and applies the hydraulic trailer brakes. The present invention may also be applied to such system.

Conventionally, the trailer brake controller is located within the towing vehicle and generates the electric activation signal only based on information about an actuation of a brake pedal and measured deceleration in the towing vehicle. Optionally, manual adjustments may be implemented by the driver via a manual control device allowing for example adapting a brake intensity to be realised by the brakes of the trailer.

US 2017/0217411 A1 discloses a brake control unit and a method for controlling braking of a towed vehicle comprising receiving a first signal via a communication bus of a towing vehicle, the first signal relating to at least one operating condition of at least one of the towing vehicle and a towed vehicle, sending a second signal to brakes of the towed vehicle, the second signal being based on said first signal.

Disclosure of the invention

In view of this background, the approach described herein presents a trailer mounted brake controller, a towing vehicle mounted brake controller and a brake controller system comprising both brake controllers, as well as a trailer, a towing vehicle and a vehicle train comprising such brake controllers and brake controller system, respectively, according to the independent claims. Advantageous embodiments are disclosed in the dependent claims as well as in the following specification.

Advantages of the invention

Embodiments of the invention may enable braking of a vehicle train comprising a towing vehicle and trailer in a more secure and/or more effective manner.

According to a first aspect of the invention, a trailer mounted brake controller for controlling operation of brakes in a trailer is proposed. The trailer mounted brake controller comprises:

- a first signal interface for receiving trailer status signals from sensors in the trailer, the trailer status signals relating to a current driving status of the trailer;
- a second signal interface for receiving towing vehicle status signals from at least one of sensors and controllers in a towing vehicle towing the trailer, the

towing vehicle status signals relating to at least one of a current driving status of the towing vehicle and an operation status of a towing vehicle brake controller;

- a third signal interface for transmitting brake control signals to brakes of the trailer; and

- a signal processor being configured for generating the brake control signals taking into account both the trailer status signals and the towing vehicle status signals.

According to a second aspect of the invention, a towing vehicle mounted brake controller for controlling operation of brakes in a towing vehicle is proposed. The towing vehicle mounted brake controller unit comprises:

- a first signal interface for receiving trailer status signals from sensors in a trailer towed by the towing vehicle, the trailer status signals relating to at least one of a current driving status of the trailer and an operation status of a trailer mounted brake controller;

- a second signal interface for receiving towing vehicle status signals from at least one of sensors and controllers in the towing vehicle, the towing vehicle status signals relating to a current driving status of the towing vehicle;

- a third signal interface for transmitting brake control signals to brakes of the towing vehicle; and

- a signal processor being configured for generating the brake control signals taking into account both the towing vehicle status signals and the trailer status signals.

According to a third aspect of the invention, a brake controller system comprising a trailer mounted brake controller according to an embodiment of the first aspect and a towing vehicle mounted brake controller according to an embodiment of the second aspect of the invention is proposed.

According to fourth and fifth aspects of the invention, a trailer comprising a trailer mounted brake controller according to the first aspect and a towing vehicle comprising a towing vehicle mounted brake controller according to the second aspect of the invention are proposed.

According to further aspects of the invention, a vehicle train comprising a towing vehicle according to the fifth aspect and a trailer according to the fourth aspect of the invention are proposed, wherein the towing vehicle status signals are supplied to the second interface of the trailer mounted brake controller via a

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5 vehicle communication network interconnecting the towing vehicle mounted
brake controller and the trailer mounted brake controller and/or wherein the trailer
status signals are supplied to the first interface of the towing vehicle mounted
brake controller via the vehicle communication network interconnecting the
towing vehicle mounted brake controller and the trailer mounted brake controller.

10 Ideas underlying embodiments of the present invention may be interpreted as
being based, inter alia, on the following observations and recognitions.

15 Recently, a trailer mounted brake controller has been developed which does not
simply send brake activation signals to the brakes of the trailer, the brake
activation signals taking into account a brake pedal actuation and, optionally,
further data relating to the towing vehicle. Instead, various sensors are comprised
in the trailer itself and the developed trailer mounted brake controller generates
20 brake activation signals taking into account the trailer-related signals from these
sensors. Particularly, such trailer mounted brake controller may provide operation
of features similar to an ABS (anti-lock braking system) or an ESC (electronic
stabilisation control – sometimes also referred to electronic stabilisation program
(ESP)) as known from modern cars. Therein, the trailer mounted brake controller
may receive for example wheel speed data from rotation rate sensors provided at
wheels of the trailer and/or acceleration data provided from acceleration sensors
within the trailer. The trailer mounted brake controller may then generate the
brake activation signals taking into account the current driving status of the trailer
25 as indicated, inter-alia, by the wheel speed data, acceleration data and possibly
further data which are influenced by current conditions in the trailer or acting on
the trailer. Thereby, the trailer brake control may generate the brake activation
signal such that a stabilisation of the trailer during a braking process may be
achieved and/or a braking efficiency may be improved.

30 It has now been found that further improvements during braking a vehicle train
comprising a towing vehicle and a trailer may be achieved by specifically
configuring the brake controller of the trailer and/or of the towing vehicle and
interconnecting the trailer and the towing vehicle via a vehicle communication
35 network in such a manner that the trailer mounted brake controller and/or the
towing vehicle mounted brake controller do not only take into account status
signals relating to its associated part of the vehicle train but also status signals
relating to the other part of the vehicle train. In other words, the trailer mounted

5
brake controller and the towing vehicle mounted brake controller should take into account both, the trailer status signals and the towing vehicle status signals, when generating the brake control signals for braking the trailer or the towing vehicle, respectively.

10
Taking into account status signals from the other part of the vehicle train may enable that the respective brake controller generates brake control signals for its associated part of the vehicle train not only taking into account the current driving status of this associated part of the vehicle but also the driving status of the other part of the vehicle train.

15
For example, the trailer mounted brake controller may not only take into account the trailer status signals relating to the current driving status of the trailer but may also take into account the towing vehicle status signals relating to the current driving status of the towing vehicle and/or to an operation status of the towing vehicle brake controller.

20
For example, upon communicating with the towing vehicle and e.g. with a ESC system comprised in the towing vehicle, the trailer mounted brake controller may learn that this ESC system is currently detecting an imminent locking of wheels of the towing vehicle during a braking procedure. Upon such information, the trailer mounted brake controller may decide to temporarily reduce brake actuation intensity such as to anticipate a lacking grip to the street and avoid any blockage of wheels of the trailer.

25
30
Generally, the towing vehicle status signals may comprise at least three types of data including longitudinal acceleration data, lateral acceleration data, yaw rate data, accelerator pedal data, brake pedal data, wheel speed data, driver steering input data and vehicle braking status data, all data relating to the towing vehicle.

35
In other words, while, conventionally, brake control signals are generated taking into account brake pedal data indicating a brake pedal actuation in the towing vehicle and, optionally, vehicle braking status data indicating a status during a braking procedure of the towing vehicle, it is now proposed to take into account at least one further type of data. This further type of data is typically supplied by sensors in the towing vehicle and is generally processed in brake controllers or drive assistance systems in the towing vehicle.

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5 For example, such further type of data may be longitudinal acceleration data indicating a current longitudinal acceleration of the towing vehicle along a drive direction, lateral acceleration data indicating a current lateral acceleration of the towing vehicle transverse to the drive direction, yaw rate data indicating a current yaw rate of the towing vehicle upon yawing around a vertical axis and/or wheel speed data indicating a current rotation speed or rotation rate of one or more wheels of the towing vehicle. Based on such towing vehicle status data, the trailer mounted brake controller may derive information indicating for example whether the towing vehicle is currently heavily decelerating, is in a side motion, is yawing, etc. This information may then be used by the trailer mounted brake controller for more suitably generating the brake control signals for braking the trailer.

10
15 Additionally, the towing vehicle status signals may further comprise at least one of ON/OFF status data and operation mode data of the towing vehicle brake controller. In other words, the towing vehicle status signals may additionally comprise ON/OFF status data providing an information indicating whether or not the brake controller of the towing vehicle is currently operating or not. Additionally or alternatively, operation mode data may provide an information about a current operation mode in which the towing vehicle mounted brake controller is currently operating.

20
25 Similarly, the trailer status signals may comprise at least one of longitudinal acceleration data, lateral acceleration data, yaw rate data, wheel speed data, brake operation data, ON/OFF status data and operation mode data of the trailer brake controller, trailer status information data, fault/shutdown data and driver information data, all data relating to the trailer. Status information can be comprised of fault / operation / shutdown status of the brake controller when a fault condition occurs. Status could also be odometer data, service interval alerts and maintenance warnings for an attached trailer. Hardware monitoring on the trailer such as trailer stand/jockey wheel up/down, trailer park brake on/off, trailer hitch latch secured/not secured. Numerous status of various sensors may be added in the future, brake hardware status (temperatures, bearing vibration, etc).

30
35 According to an embodiment, the towing vehicle mounted brake controller may further comprise a signal output device for outputting an indicator signal in the towing vehicle depending on the trailer status signals. The signal output device may output the indicator signal visually, acoustically, haptically or in any other

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5 way perceptible by the driver. For example, the signal output device may be a set of light sources such as LEDs, a display, a screen, a loudspeaker, etc. By including such signal output device into the towing vehicle brake controller, additional information may be supplied to the driver, such additional information relating for example to an operation status of the trailer mounted brake controller and/or to a current driving status of the trailer.

10 According to an embodiment of the vehicle train comprising the towing vehicle and the trailer, the vehicle communication network may be a CAN-bus network, a Flex-ray network, a LIN network or an Ethernet network. Optionally, also wireless networks such as e.g. Bluetooth, Wifi, etc. may be applied. All such types of networks may be applied in vehicles for exchanging signals and data for example between sensors and/or controllers. In the approach described herein, such networks may be used for exchanging trailer status signals and/or towing vehicle status signals from the trailer towards the towing vehicle, or more specifically from the trailer mounted brake controller towards the towing vehicle brake controller, and/or vice versa from the towing vehicle towards the trailer.

15
20 Particularly, the vehicle communication network may be configured for transmitting signals bidirectionally between the towing vehicle and the trailer. In other words, signals or data may be transmitted via the vehicle communication network in a first direction for example from the towing vehicle mounted brake controller towards the trailer mounted brake controller and/or in an opposite direction from the trailer mounted brake controller towards the towing vehicle mounted brake controller.

25
30 It is to be noted that possible features and advantages of the invention are described herein with reference to different embodiments relating to the trailer mounted brake controller, the towing vehicle mounted brake controller, the brake controller system comprising both brake controllers and to a trailer, a towing vehicle and a vehicle train comprising such brake controllers. One skilled in the art understands that features may be suitably combined, adapted and/or exchanged in order to arrive at further embodiments of the invention.

35 Brief description of the drawings

Embodiments of the invention will be described in the following in relation to the enclosed drawing. However, neither the drawing nor the description shall limit the invention.

5 Fig. 1 shows a vehicle train comprising a towing vehicle and the trailer including a brake controller system with a towing vehicle mounted brake controller and a trailer brake mounted controller in accordance with an embodiment of the present invention.

10 The drawing is only represented in a schematic manner and is not to scale.

Embodiments of the invention

15 Fig. 1 shows a vehicle train 1 including a towing vehicle 3 and a trailer 5. The towing vehicle 3 comprises a towing vehicle mounted brake controller 7. The trailer 5 comprises a trailer mounted brake controller 9.

20 In the trailer 5, various sensors 15 are comprised. For example, wheel sensors 11 may sense wheel speed data or rotation rate data of wheels 17 of the trailer 5. Furthermore, an inertial sensor 13 may provide data about longitudinal accelerations, lateral accelerations and/or a yaw rate in the trailer 5. All these sensors 15 may provide trailer status signals to the trailer mounted brake controller 9, these trailer status signals relating to a current driving status of the trailer 5.

25 Similarly, various sensors (not explicitly shown) are comprised in the towing vehicle 3 and provide towing vehicle status signals to the towing vehicle mounted brake controller 7 for providing information relating to a current driving status of the towing vehicle 3.

30 The towing vehicle 3 and its towing vehicle mounted brake controller 7 are connected via a vehicle communication network 25 to the trailer 5 and its trailer mounted brake controller 9. The vehicle communication network 25 may transmit signals and data bidirectionally, i.e. from the towing vehicle 3 to the trailer 5 and vice versa.

35

Accordingly, the trailer mounted brake controller 9 may receive towing vehicles status signals from at least one of the sensors or controllers provided in the towing vehicle 3 via a second signal interface 21.

5 Taking into account both, the trailer status signals as well as the towing vehicle status signals, a signal processor 27 in the trailer mounted brake controller 9 may generate brake control signals to be submitted to brakes provided at the wheels 17 of the trailer 5 via a third signal interface 23.

10 Similarly, the towing vehicle mounted brake controller 7 may comprise first, second and third signal interfaces (not explicitly shown) for receiving the trailer status signals, for receiving the towing vehicle status signals and for transmitting the brake control signals to brakes of the towing vehicle, the brake control signals having been generated by a signal processor taking into account both, the towing vehicle status signals and the trailer status signals.

15 As part of the towing vehicle mounted brake controller 7, a signal output device 29 may be provided within the towing vehicle 3 for outputting an indicator signal depending on the trailer status signals. The signal output device 29 may receive the trailer status signals via the data communication network 25. The trailer status signals may be processed or may be directly output as indicators signals. For example, such trailer status signals may indicate whether or not the trailer mounted brake controller 9 is currently operating correctly. Optionally, the signal output device 29 may also include input means allowing for example a driver to manually input data, thereby for example modifying characteristics of the trailer mounted brake controller 9. The signal output device 29 may be for example a screen or a set of LEDs.

20 In the following, possible features and advantages of embodiments of the brake controllers, brake controller system, trailer, towing vehicle and vehicle train proposed herein will be described in more detail with respect to exemplary implementations.

25 30 35 Electric trailer braking control from the tow-vehicle to the trailer is currently, generally the performed by a single service brake signal. This service brake signal generally adjusts a braking power level to the trailer based on very simplified settings of driver braking gain selection, in-vehicle brake controller inertia and a number of uncontrollable settings (signal voltages, wire and

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connector resistances). Electric Trailer Brake Controllers are supplied as either an OEM vehicle integrated controller or as an aftermarket installation.

5 Existing electric braking systems from the tow-vehicle to the trailer may have a multitude of control issues from locking trailer wheels, to under braking the trailer, not detecting failures on the trailer braking systems. Non-synchronised control between the tow vehicle and the trailer can lead to sub optimal brake control.

10 Recently, a new trailer braking product has been developed, sometimes referred to as Trailer Safety Control (TSC). Embodiments of the invention described herein a to expand the developed system to more advanced control with the integration into existing tow vehicle trains. Particularly, an ESP ECU (electronic control unit) may have the ability for additional software-based Value Added Functions (VAF) which are offered to OEM manufacturers when quoting for the development of a
15 new vehicle.

20 This proposal is for a new ESP ECU VAF sometimes referred to as “Advanced Trailer Control”. This VAF will provide to communications channel from the braking system (ESP) on the tow vehicle to the TSC product, generally mounted on the towed trailer, via a vehicle communication network (i.e. CAN-bus, Flex-ray, LIN or Ethernet), and thereby provide an integrated braking control method between tow vehicle and trailer.

25 A system solution is to connect the trailer based TSC controller to the towing vehicle braking system, via vehicle communication network, for improved vehicle & trailer braking response, dynamics and driver feedback.

30 Embodiments of the proposed brake controller may be offered to OEM manufacturers as an advanced trailer control system. Particularly, this VAF may be of value to vehicles manufacturers and customers in the Australian and America market where the TSC product is to be applied, particularly to manufacturers which develop large towing vehicles that currently contain integrated electric trailer brake controllers. This VAF will allow manufacturers to add advanced trailer braking control to their vehicles for use by customers who
35 own a trailer with a TSC product fitted.

Embodiments of the proposed brake controller may provide detailed driver intention information to the Trailer Safety Control system. Driver braking and

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5 vehicle control intentions can be sent to the TSC brake controller to improve overall vehicle-train braking control. Data sent could include but not be limited to driver pedal signals (accelerator, and brake pedal), steering input and vehicle lights control data.

10 Furthermore, detailed vehicle dynamics information may be provided to the trailer brake controller. Tow Vehicle Dynamic information can be sent to the TSC braking controller to improve and increase the functionality in the TSC product. This could include tow vehicle inertia signals (Ax, Ay, Yaw), ESP System Status (ABS, TSC, ESP, HHC (hill hold control), HDC (hill descent control) active), Wheel Speed Information, Vehicle Ignition Information. Numerous other signals from ESP may be utilised in further TSC function development.

15 A driver visual interface serving as signal output device may be provided for trailer control. Advanced driver feedback could be offered on the tow-vehicle instrument cluster for the trailer. Information provided could include braking operation, trailer warnings, trailer braking system status, trailer control enable/disable, braking override operation and many more.

20 Furthermore, detailed trailer dynamic information may be provided to the towing vehicle for brake control. The towing vehicle could improve its braked towing dynamics of functions such as ABS, ESP, HHC, HDC with detailed trailer information including, inertia signals (Ax, AY, Yaw) of the trailer mounted TSC, trailer braking functions (ABS, TSM) activation can be sent to the tow vehicle for
25 improved control.

30 Finally, it should be noted that the term “comprising” does not exclude other elements or steps and the “a” or “an” does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims:

1. Trailer mounted brake controller for controlling operation of brakes in a trailer, the trailer mounted brake controller comprising
a first signal interface for receiving trailer status signals from sensors in the trailer, the trailer status signals relating to a current driving status of the trailer;
a second signal interface for receiving towing vehicle status signals from at least one of sensors and controllers in a towing vehicle towing the trailer, the towing vehicle status signals relating to at least one of a current driving status of the towing vehicle and an operation status of a towing vehicle mounted brake controller;
a third signal interface for transmitting brake control signals to brakes of the trailer;
a signal processor being configured for generating the brake control signals taking into account both the trailer status signals and the towing vehicle status signals.
2. Towing vehicle mounted brake controller for controlling operation of brakes in a towing vehicle, the towing vehicle mounted brake controller comprising
a first signal interface for receiving trailer status signals from sensors in a trailer towed by the towing vehicle, the trailer status signals relating to at least one of a current driving status of the trailer and an operation status of a trailer mounted brake controller;
a second signal interface for receiving towing vehicle status signals from at least one of sensors and controllers in the towing vehicle, the towing vehicle status signals relating to a current driving status of the towing vehicle;
a third signal interface for transmitting brake control signals to brakes of the towing vehicle;
a signal processor being configured for generating the brake control signals taking into account both the towing vehicle status signals and the trailer status signals.
3. Controller of any one of the preceding claims, wherein the towing vehicle status signals comprise at least three of longitudinal acceleration data, lateral acceleration data, yaw rate data, accelerator pedal data, brake pedal data,

- wheel speed data and vehicle braking status data, all data relating to the towing vehicle.
4. Controller of any one of the preceding claims, wherein the towing vehicle status signals further comprise at least one of ON/OFF status data and operation mode data of the towing vehicle mounted brake controller.
 5. Controller of any one of the preceding claims, wherein the trailer status signals comprise at least one of longitudinal acceleration data, lateral acceleration data, yaw rate data, wheel speed data, brake operation data, ON/OFF status data and operation mode data of the trailer brake controller, trailer status information data and driver information data, all data relating to the trailer.
 6. Controller of claim 2, further comprising a signal output device for outputting an indicator signal in the towing vehicle depending on the trailer status signals.
 7. Brake controller system comprising a trailer mounted brake controller of claim 1 and a towing vehicle mounted brake controller of claim 2.
 8. Trailer comprising a trailer mounted brake controller of claim 1.
 9. Towing vehicle comprising a towing vehicle mounted brake controller of claim 2.
 10. Vehicle train comprising a towing vehicle of claim 9 and a trailer of claim 8, wherein the towing vehicle status signals are supplied to the second interface of the trailer mounted brake controller via a vehicle communication network interconnecting the towing vehicle mounted brake controller and the trailer mounted brake controller.
 11. Vehicle train comprising a towing vehicle of claim 9 and a trailer of claim 8, wherein the trailer status signals are supplied to the first interface of the towing vehicle mounted brake controller via a vehicle communication network interconnecting the towing vehicle mounted brake controller and the trailer mounted brake controller.

12. Vehicle train comprising a towing vehicle of claim 9 and a trailer of claim 8, wherein the towing vehicle status signals are supplied to the second interface of the trailer mounted brake controller via a vehicle communication network interconnecting the towing vehicle mounted brake controller and the trailer mounted brake controller and wherein the trailer status signals are supplied to the first interface of the towing vehicle mounted brake controller via the vehicle communication network interconnecting the towing vehicle mounted brake controller and the trailer mounted brake controller.
13. Vehicle train of any one of claims 10 to 12, wherein the vehicle communication network is one of a CAN-bus network, a Flex-ray network, a LIN network and an Ethernet network.
14. Vehicle train of any one of claims 10 to 13, wherein the vehicle communication network is transmitting signals bidirectionally between the towing vehicle and the trailer.

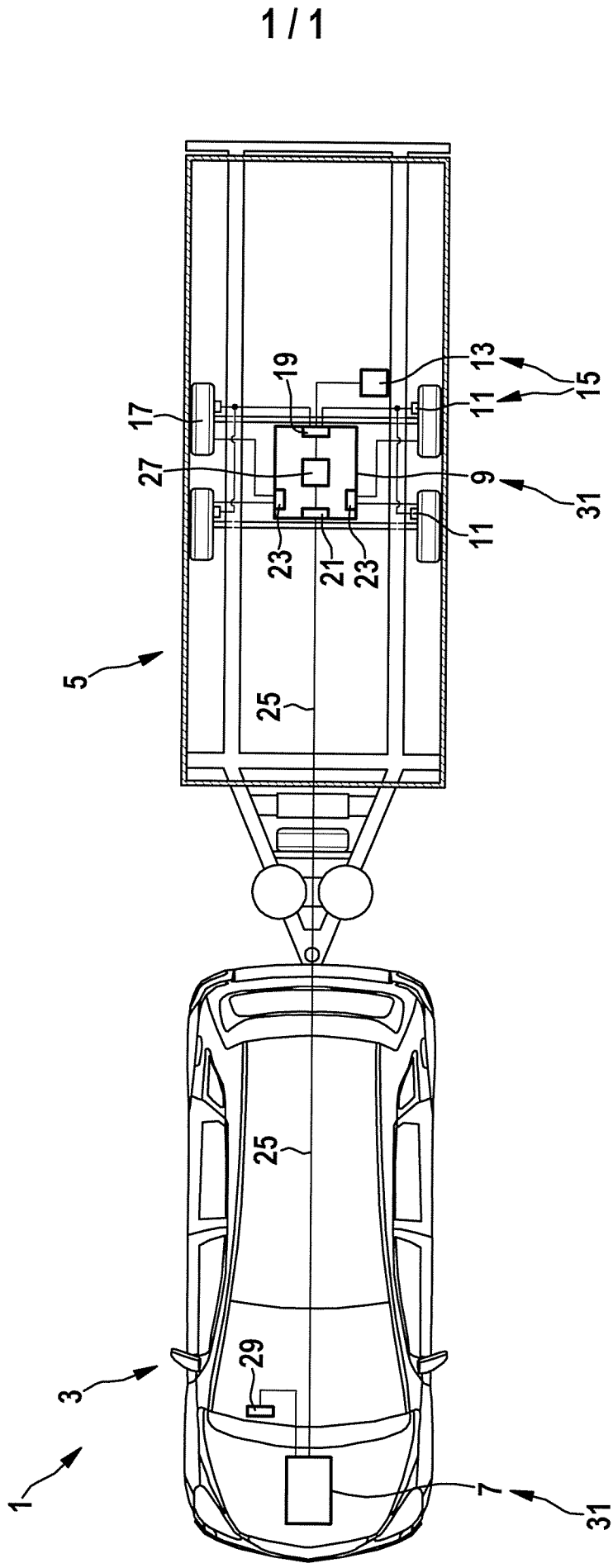


Fig. 1