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(54) Title: A STEERING CONTROL SYSTEM AND METHOD

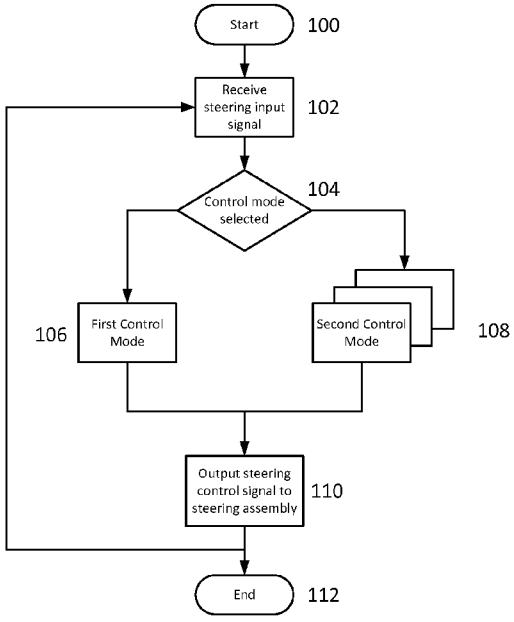

Fig. 3

(57) Abstract: A system and method for steering control of a vehicle, preferably an agricultural tractor, is described. The system can be operated in a first control mode, which provides directly proportional steering control, or in an alternative control mode, where the output steering control signal is not directly proportional to the input. Examples of alternative control modes comprise pulse width control, pulse height control, a moving average filter control. The provision of different steering control modes allows for the selection of the control mode most suitable for the current steering operation and/or steering input device.

A Steering Control System and Method

Field of the Invention

The present invention relates to a system and method for steering control of an agricultural vehicle.

Background of the Invention

Traditionally, vehicle steering systems have relied on a direct mechanical connection between a vehicle steering wheel and the steering linkages, such that a movement of the steering wheel in either direction results in a directly proportional adjustment of the orientation of the associated ground contacting elements (e.g. wheels, tracks, etc.).

In many modern agricultural vehicles, the direct mechanical connection has been replaced by an electrohydraulic system, wherein sensors are arranged to monitor the status of the steering wheel and to report any movement to an electronic controller. The controller is then operable to command an array of hydraulic actuators to adjust the steering assembly as appropriate.

Electrohydraulic steering systems can allow for tuning of the steering response, by adjustment of the steering transfer function. In addition, the use of such electrohydraulic steering systems allows for additional or alternative steering input devices to be easily incorporated into a steering system, e.g. joystick steering devices.

Due to the relatively low speeds at which agricultural vehicles commonly operate at, e.g. during tillage operations such as ploughing, any adjustments to the steering direction need to be continuously applied until the vehicle has travelled sufficient distance to complete the course correction. Such actions can impact on the user comfort, as they are required to maintain the steering adjustment for extended periods of time.

It is an object of the invention to provide an improved steering control system and method.

Summary of the Invention

Accordingly, there is provided a method of controlling a steering input for an agricultural vehicle such as an agricultural tractor, a harvester, or an agricultural applicator vehicle, the method comprising the steps of:

receiving a steering input signal from a steering input device operated by a user; and

outputting a steering control signal to a steering assembly for steering of the agricultural vehicle, the steering control signal based on the received steering input signal,

wherein the method selects between:

a first control mode wherein the steering control signal is substantially directly proportional to the received steering input signal, and

at least one further control mode wherein the steering control signal is not substantially directly proportional to the received steering input signal.

The transfer function provided by the control method between the steering input signal and the output steering control signal can be changed based on the system requirements. By providing a second steering control mode which is not a direct proportional control of the steering assembly, the flexibility of the vehicle steering can be improved, as the user has different options as to how the steering is adjusted. Such options can provide for greater ease of use and increased user comfort during vehicle operation. The method is used for the control of steering of agricultural vehicles such as agricultural tractors, harvesters or applicators e.g. sprayers, wherein the selection of different steering modes can provide a particular advantage for operator comfort and ease of operation of the vehicle.

In the first control mode, providing the steering output signal to be substantially directly proportional to the steering input signal will be understood to be equivalent to the regular steering operation of prior art systems, where the instantaneous steering input signal produces a corresponding instantaneous steering control signal correlating with a direct representation of the steering output. As the further control mode is non-directly proportional to the steering input signal, the user can be presented with a different control scheme which may be more suitable to the current steering requirements.

Preferably, the method comprises the step of receiving a user input selecting between the first control mode and the at least one further control mode.

Accordingly, the user may be able to select the preferred control mode for the current steering operation.

Preferably, the method is arranged to select between a plurality of different control modes which are not substantially directly proportional to the received steering input signal.

Providing a variety of non-directly proportional control modes allows for the user to have a range of different control schemes, which provide for greater flexibility in selecting an appropriate control mode for the current steering requirements.

In one aspect, the at least one further control mode comprises wherein the steering control signal is output as the integral value of the steering input signal. The at least one further control mode can operate wherein the steering control signal is the output of a pulse width modulation analysis of the steering input signal.

With this control mode, a user can effectively control vehicle steering through one-off, or pulsed, steering actions. Such pulsed movements of the steering input device can provide a more comfortable method of steering when using some steering devices, e.g. when using joystick-based control.

In an additional or alternative aspect, the at least one further control mode comprises identifying discrete steering input signal pulses, and wherein the output of the steering control signal is based on the peak value of an identified steering input signal pulse.

Pulse height control can provide for a system for rapid changes of steering direction. It will be understood that the output of the steering control signal is held at the peak value of an identified steering input signal pulse until a succeeding pulse is identified, at which point the output of the steering control signal is changed to the peak value of the new pulse.

In this case, it will be understood that the factors for identifying a steering input pulse, e.g. pulse duration, minimum magnitude, etc., may be predefined and/or may be adjustable by the user.

In an additional or alternative aspect, the at least one further control mode comprises wherein the steering control signal is the output of a moving average filtering of the steering input signal.

The use of a moving average filter steering system provides a system having a relatively gentle response to steering actions, and which can smooth out relatively large changes in

steering. Such a system can provide an appropriate steering solution during relatively delicate steering operations, e.g. so that a tractor is not steered onto valuable crops.

Preferably, the at least one further control mode is arranged such that the responsiveness of the moving average filtering can be adjusted, preferably by the user.

It will be understood that the control method can be arranged to select between the first control mode and any one or more of the above-described further control modes.

Preferably, the method comprises the steps of:

receiving a first signal from a first steering input device operated by a user, and

receiving a second signal from a second steering input device operated by a user,

wherein the output steering control signal is based on the first signal or the second signal as the steering input signal.

Preferably, the method comprises the step of receiving a user input to select the first signal or the second signal as the steering input signal.

In some vehicles, more than one steering input device may be available for use. In such cases, a user may select which input device is to be the monitored as the main input device, providing the steering input signal. The steering input devices may be selected from at least one or more of the following: a steering wheel; a joystick, a trackball controller, a touchscreen controller.

Preferably, the method comprises the steps of:

when the first input signal is selected as the steering input signal, operating in the first control mode, and

when the second input signal is selected as the steering input signal, operating in the at least one further control mode.

In an additional or alternative aspect, different steering input device may have different default steering control modes associated therewith, for example a steering wheel may default to a normal directly-proportional control mode, while a joystick controller may default to a pulse width control mode or an integral control mode. Such default control modes may be predefined, and/or may be selected by a user in a system configuration setting.

The method may further comprise the steps of:

receiving a return-to-zero-steering command for a user; and

on receipt of said return-to-zero-steering command, the steering control signal is output to command the steering assembly to return to a zero or neutral steering position.

The use of a return-to-neutral command allows for an easy way to reset the steering output of the steering assembly, which may be advantageous when using a non-directly proportional control mode. The return-to-zero-steering command may further be configured to reset the steering control modes to a starting condition. Such a reset command can increase the usability of integral or moving average control modes.

Preferably, the method is configured to control the operation of a steering input device, wherein the method comprises the steps of:

when in the first control mode, operating the steering input device as a self-centring input device; and

when in the at least one further control mode, operating the steering input device as a non-centring input device.

As the input device may be switched between a self-centring and a non-centring mode, depending on the control mode used, accordingly the operator may more easily comprehend which control mode is currently used, and the operator may more intuitively understand how to use the current control mode.

There is further provided a controller for an agricultural vehicle steering system arranged to implement any of the steps of the above-described method.

There is further provided a steering input control system for an agricultural vehicle, the steering input control system comprising:

at least one steering input device to be operated by a user, providing a steering input signal; and

a controller arranged to receive the steering input signal from the input device and to output a steering control signal to a steering assembly for steering of the vehicle, the steering control signal based on the received steering input signal,

wherein the steering input control selects between:

a first control mode wherein the steering control signal is substantially directly proportional to the received steering input signal, and

at least one further control mode wherein the steering control signal is not directly proportional to the received steering input signal.

Preferably, the steering input control system further comprises a user interface device.

Preferably, the controller receives a user input from the user interface device selecting between the first control mode and the at least one further control mode.

In one aspect, the steering input control system comprises at least a first steering input device to provide a first signal and at least a second steering input device to provide a second signal, wherein the output steering control signal is based on the first signal or the second signal as the steering input signal.

Preferably, the controller receives a user input from the user interface device to select the first steering input signal or the second steering input signal as the steering input signal.

Preferably, the at least one steering input device is selected from at least one or more of the following: a steering wheel; a joystick, a trackball controller, a touchscreen controller.

Preferably, the at least one steering input device comprises a self-centring input device, wherein the self-centring input device returns to a zero or neutral steering position upon release by an operator.

Additionally or alternatively, the at least one steering input device comprises a non-centring input device, wherein the non-centring input device remains in the active position upon release by an operator.

Preferably, the steering input control system controls the at least one steering input device wherein:

when in the first control mode, the at least one steering input device operates as a self-centring input device; and

when in the at least one further control mode, the at least one steering input device operates as a non-centring input device.

Preferably, the steering input control system comprises a return-to-zero-steering module, which is selectable to command the steering assembly to return to a zero or neutral steering position.

Preferably, the return-to-zero-steering module is selectable by a user, preferably using the user interface device.

The system may comprise a reset command device, wherein on actuation of such a device, the steering control modes are reset to a starting condition.

There is further provided an agricultural vehicle, preferably an agricultural tractor, having a steering input control system as described above.

Detailed Description of the Invention

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is an illustration of an agricultural tractor according to the invention;

Fig. 2 is a schematic of a steering control system for the agricultural tractor of Fig. 1;

Fig. 3 is a process diagram for a steering control method according to the invention;

Fig. 4 is a process diagram for a portion of the control method of Fig. 3; and

Figs. 5-8 are sample plots of different control modes of the steering control method of the invention.

In Fig. 1, a vehicle in the form of an agricultural tractor is indicated at 10. The tractor 10 comprises front wheels 12, rear wheels 14, an engine section 16 and a cab section 18. The tractor 10 further comprises at least one Electronic Control Unit (ECU) 20, which is arranged to control operation of various tractor systems. The cab section 18 is provided with operator controls 22 for operation of the different components of the tractor 10, including hydraulics, electrical systems, HVAC, etc. The operator controls 22 may comprise mechanical levers and/or electronic control systems incorporating configurable switches, touchscreen displays, etc.

The tractor 10 further provided with at least one steering input device to control the steering of the tractor 10. In the embodiment shown, the tractor 10 is provided with a steering wheel 24 and a joystick controller 26, either of which may be used to steer the tractor 10. Additionally, the tractor 10 may be steered using inputs received from the operator controls 22. For example, the tractor 10 may be controlled using commands input into the controls 22, or by modules or software programs operating on an electronic device, which may be provided as part of the operator controls 22. It will be understood that the ECU 20 is provided in communication with the operator controls 22, and with the steering wheel 24 and joystick controller 26.

While the agricultural tractor 10 is shown as being a wheeled tractor, it will be understood that the invention may also be used on tracked tractors or agricultural harvesters. It will be understood that the invention is preferably intended for use with agricultural vehicles having power outputs of greater than 100hp.

With reference to Fig. 2, a steering input control system for the tractor 10 is generally indicated at 28. The ECU 20 is connected with a front axle steering assembly 30, which controls the steering orientation of the front wheels 12. It will be understood that the front axle steering assembly 30 can comprise any known steering assembly configuration, such as an electric, hydraulic, or pneumatic steering system. Preferably, the steering assembly comprises an electrohydraulic steering system, which can be controlled by electric signals from the ECU 20.

In the embodiment of Fig. 2, the ECU 20 is also connected to a rear axle steering assembly 32, which controls the steering orientation of the rear wheels 14. Such dual axle or four-wheel steering systems are provided on some vehicles having improved steering response and reduced turning radius, but it will be understood that for the majority of systems the ECU 20 will be only connected with a single steering assembly.

The ECU 20 is configured to control the steering of the vehicle in at least two different control modes, a first mode which produces a steering output signal which is substantially directly proportional to the received steering input, and at least one further control mode where the steering output signal is not directly proportional to the received steering input. The provision of alternate steering control modes allows for a greater flexibility in control of the vehicle steering.

The operation of the control method will now be described, with reference to Figs. 3-8. Figs. 3 and 4 illustrate embodiments of the control method of the invention. Figs. 5-8 provide a series of sample plots of inputs and the resulting outputs of the steering control system against time (in seconds), illustrating examples of different control modes which may be employed by the control method. In the sample plots, the input and output data is represented as the signal produced for the extent of actuation of the steering input device or the steering assembly ranging between full actuation in a first direction (+100%) and full actuation in the opposite direction (-100%).

The steering control method is initialised with the starting of the tractor 10, step 100. The ECU 20 receives a steering input signal, step 102, from a steering input device 22,24,26. The steering input signal is indicative of a user-controlled actuation of the steering input device 22,24,26, and the degree to which the device is moved to the left or to the right.

The ECU 20 determines which control mode is selected for the steering operation, step 104. Based on which control mode is selected, the ECU 20 performs a different processing of the received steering input signal, and outputs the processed steering control signal to the associated steering assembly 30,32 of the tractor 10.

If a first control mode of the steering control system is selected, step 106, the ECU 20 is configured to output a steering control signal which is substantially directly proportional to the received steering input signal. Such an output will correspond to the normal known steering control of prior art vehicles. Fig. 5 provides an example of the input/output relation, wherein a 100% actuation of the steering input signal results in a 100% actuation of the output steering control signal. It will be understood that the output signal may not follow an exact direct relationship, and the ECU 20 may be configured to perform some scaling of the output signal.

If an alternative control mode of the steering control system is selected, step 108, the ECU 20 is configured to output a steering control signal based on, but not directly proportional to, the received steering input signal. The control method is arranged to provide one or more alternate control modes, examples of which are shown in Figs. 6-8.

In Fig. 6, an example is shown of an integral control mode, or a pulse width control. In this control mode, the output signal is effectively a summation of the measured input signal. In Fig. 6, the input is initially at 0%, or the neutral steering location, and is then gradually

raised to +40% before returning to 0%. The integrated output accordingly rises in line with the cumulative magnitude of the input signal to +20%, +60%, and then +80%. The steering output is held at 80% after the input returns to 0%, until the input signal is moved to -40%, resulting in a corresponding adjustment in the output signal from +80% to +40%. Again, the output steering control signal is held at the new value of +40% after the input signal returns to 0%. A further adjustment of the input signal to -60% for two seconds results in the output signal moving to -80%. This provides a steering output which is a pulse width modulation of the input signal.

The use of such an integral control mode allows for simple directional control and course correction, without requiring continual actuation of the steering input. Accordingly, such a control mode is particularly suitable for use with a joystick controller or similar, as a user can change the steering direction, and cause it to be held at such a direction, through a simple actuation of the joystick in either direction. This steering control mode is particularly useful when a tractor is performing a relatively low-speed operation, and consequently any turning manoeuvres require maintaining a turned steering direction for a relatively long period of time in order to complete the turn.

In Fig. 7, an example of a further control mode is shown, based on the same steering input signal as in Fig. 6. The mode illustrated in Fig. 7 relies on pulse height control to provide the output steering control signal. Accordingly, the ECU 20 is configured to identify a discrete pulse in the steering input signal, and to output a steering control signal to the associated steering assembly 30,32 based on the peak magnitude of the identified pulse. The peak value is maintained at the output, until a succeeding input pulse is identified, setting a new output value.

In the example of Fig. 7, the output is raised to the peak of +40%, as indicated by the first input pulse. The output remains at +40% until the input is set to -40%, at which point the output signal immediately corrects to follow the peak of the second identified pulse. Finally, when the input signal is pulsed to -60%, the ECU 20 corrects the output signal to the new peak value of -60%, and maintains this level of output.

Pulse height control can provide for a system for rapid changes of steering direction, and may be particularly suitable for quick changes of steering direction, e.g. using a joystick controller. It will be understood that the ECU 20 may be configured to identify different input pulses based on a variety of factors, e.g. pulse duration, minimum magnitude, etc.

Such factors may be predefined and/or may be adjustable by the user to provide for further flexibility of control.

A further example of a possible control mode is illustrated in Fig. 8, which provides a moving average filtering of the input signal. In this control mode, the ECU 20 is configured to output an average of the input signal over a timeframe or window. In the example shown in Fig. 8, the filtering window is based on a 3-second window. Such a moving average filter steering system provides a system having a relatively gentle response to steering actions, and which can smooth out relatively large changes in steering. Such a system can provide an appropriate steering solution during relatively delicate steering operations, e.g. so that a tractor is not steered onto valuable crops. It will be understood that the filter characteristics of this control mode, such as the filter window length, filter gain, etc., can be adjusted, preferably by the user.

Returning to Fig. 3, once the ECU 20 has processed the steering input signal according to the transfer function of the selected control mode, the ECU 20 outputs the resultant steering control signal to the associated steering assembly 30,32, step 110. The steering assembly 30,32 is then configured to adjust the steering direction of the front and/or rear wheels 12,14 according to the steering control signal.

The control method is then configured to return to step 102, to receive a further steering input signal, or to end, step 112.

It will be understood that a user may be able to select the required control mode of the steering control system 28 through selection of the appropriate mode using the operator controls 22.

In the illustrated embodiment, the tractor 10 is provided with more than one steering input device 22,24,26. Accordingly, a user may be able to select which of the different input devices produce the steering input signal. An example of such a subroutine is illustrated in Fig. 4.

When the control system is started, step 200, a user may be prompted to select the preferred steering input device, step 202, for example using a menu displayed via the operator controls 22. Alternatively, the user can change the selection of the preferred steering input device at any time during operation of the tractor 10. The default selection

will normally be that the steering wheel 24 is the selected steering input device, such that the output of the steering wheel 24 is monitored as the first steering input signal, step 204. Alternatively, if the user selects an alternative input device, such as the joystick 26, accordingly the output of the joystick 26 is monitored as the second steering input signal, step 206.

When the preferred input has been selected, the ECU 20 is configured to select the monitored steering input as the steering input signal for the control method, step 208, which is accordingly used as the input at step 102 of the process of Fig. 3. The subroutine may continue until the system is finished, step 210.

It will be understood that the control system 28 may be configured such that default control modes may be associated with the different steering input devices. For example, the steering wheel 24 may default to a normal directly-proportional control mode, while the joystick controller 26 may default to a pulse width control mode or an integral control mode.

The control system 28 may further comprise a return-to-zero or return-to-neutral module, which can be activated using the operator controls 22. On activation of such a module, the ECU 20 is configured to command the associated steering assembly 30,32 to return the wheels 14,16 to a zero or straight-line steering orientation. Such a return-to-zero command may further act to reset any steering control modes to an initial starting condition.

In a further aspect of the invention, the steering input device may be used in a self-centring mode, wherein such a self-centring input device returns to a zero or neutral steering position upon release by an operator. Additionally or alternatively, the steering input device may be used on a non-centring mode, wherein such a non-centring input device remains in the active position upon release by an operator.

In a preferred aspect, the control system 28 is arranged to control the operating mode of the steering input device, to select between said self-centring mode and said non-centring mode. Accordingly, the control system 28 is configured the select the operating mode of the input device, wherein:

when the control system 28 is operating in the first control mode, the steering input device is operated as a self-centring input device; and

when the control system 28 is operating in the at least one further control mode, the steering input device is operated as a non-centring input device.

As the input device may be switched between a self-centring and a non-centring mode, depending on the control mode used, accordingly the operator may more easily comprehend which control mode is currently used, and the operator may more intuitively understand how to use the current control mode.

The use of a steering control system and method having an alternative to directly-proportional steering control allows for greater steering flexibility and control, and increased user comfort.

The invention is not limited to the embodiments described herein, and may be modified or adapted without departing from the scope of the present invention.

CLAIMS

1. A method of controlling a steering input for an agricultural vehicle such as an agricultural tractor, a harvester, or an agricultural applicator vehicle, the method comprising the steps of:

receiving a steering input signal from a steering input device operated by a user; and

outputting a steering control signal to a steering assembly for steering of the vehicle, the steering control signal based on the received steering input signal,

wherein the method selects between:

a first control mode wherein the steering control signal is substantially directly proportional to the received steering input signal, and

at least one further control mode wherein the steering control signal is not substantially directly proportional to the received steering input signal.

2. The method of claim 1, wherein the method comprises the step of receiving a user input selecting between the first control mode and the at least one further control mode.

3. The method of claim 1 or claim 2, wherein the at least one further control mode comprises wherein the steering control signal is output as the integral value of the steering input signal.

4. The method of any one of claims 1-3, wherein the at least one further control mode comprises identifying discrete steering input signal pulses, and wherein the output of the steering control signal is based on the peak value of an identified steering input signal pulse.

5. The method of any one of claims 1-4, wherein the at least one further control mode comprises wherein the steering control signal is the output of a moving average filtering of the steering input signal.

6. The method of any preceding claim, wherein the method comprises the steps of:

receiving a first signal from a first steering input device operated by a user, and

receiving a second signal from a second steering input device operated by a user,

wherein the output steering control signal is based on the first signal or the second signal as the steering input signal.

7. The method of claim 6, wherein the method comprises the step of receiving a user input to select the first signal or the second signal as the steering input signal.

8. The method of claim 6 or claim 7, wherein the method comprises the steps of:

when the first input signal is selected as the steering input signal, operating in the first control mode, and

when the second input signal is selected as the steering input signal, operating in the at least one further control mode.

9. The method of any preceding claim, wherein the method comprises the steps of:

receiving a return-to-zero-steering command for a user; and

on receipt of said return-to-zero-steering command, outputting the steering control signal to command the steering assembly to return to a zero or neutral steering position.

10. The method of any preceding claim, wherein the method is configured to control the operation of a steering input device, the method comprising the steps of:

when in the first control mode, operating the steering input device as a self-centring input device; and

when in the at least one further control mode, operating the steering input device as a non-centring input device.

11. A controller for an agricultural vehicle steering system arranged to implement the method of any one of claims 1-10.

12. A steering input control system for an agricultural vehicle such as an agricultural tractor, a harvester, or an agricultural applicator vehicle, the steering input control system comprising:

at least one steering input device to be operated by a user, providing a steering input signal; and

a controller arranged to receive the steering input signal from the input device and to output a steering control signal to a steering assembly for steering of the vehicle, the steering control signal based on the received steering input signal,

wherein the steering input control selects between:

a first control mode wherein the steering control signal is substantially directly proportional to the received steering input signal, and

at least one further control mode wherein the steering control signal is not directly proportional to the received steering input signal.

13. The steering input control system of claim 12, wherein the system further comprises at least a first steering input device to provide a first signal and at least a second steering input device to provide a second signal, wherein the output steering control signal is based on the first signal or the second signal as the steering input signal.

14. The steering input control system of claim 12 or claim 13, wherein the at least one steering input device is selected from at least one or more of the following: a steering wheel; a joystick, a trackball controller, a touchscreen controller.

15. The steering input control system of any one of claims 12-14, wherein the steering input control system comprises a return-to-zero-steering module, which is selectable to command the steering assembly to return to a zero or neutral steering position.

16. The steering input control system of any one of claims 12-15, wherein the at least one steering input device comprises a self-centring input device, wherein the self-centring input device returns to a zero or neutral steering position upon release by an operator.

17. The steering input control system of any one of claims 12-16, wherein the at least one steering input device comprises a non-centring input device, wherein the non-centring input device remains in the active position upon release by an operator.

18. The steering input control system of any one of claims 12-17, wherein the steering input control system controls the at least one steering input device wherein:

when in the first control mode, the at least one steering input device operates as a self-centring input device; and

when in the at least one further control mode, the at least one steering input device operates as a non-centring input device.

19. The steering input control system of any one of claims 12-18, comprising the controller of claim 11.

20. An agricultural vehicle, preferably an agricultural tractor, a harvester, or an agricultural applicator vehicle, having a steering input control system as claimed in any one of claims 12-19.

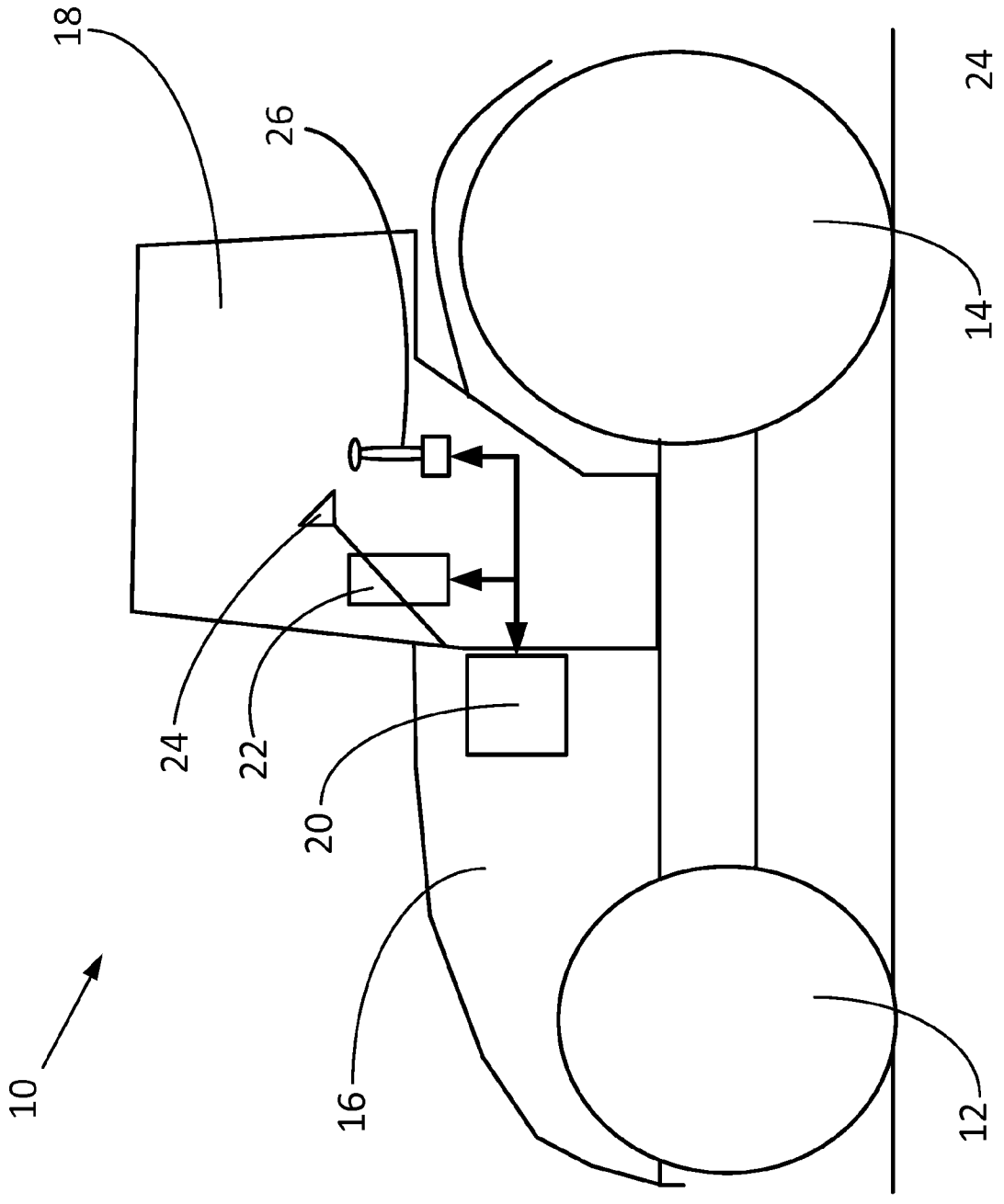

Fig. 1

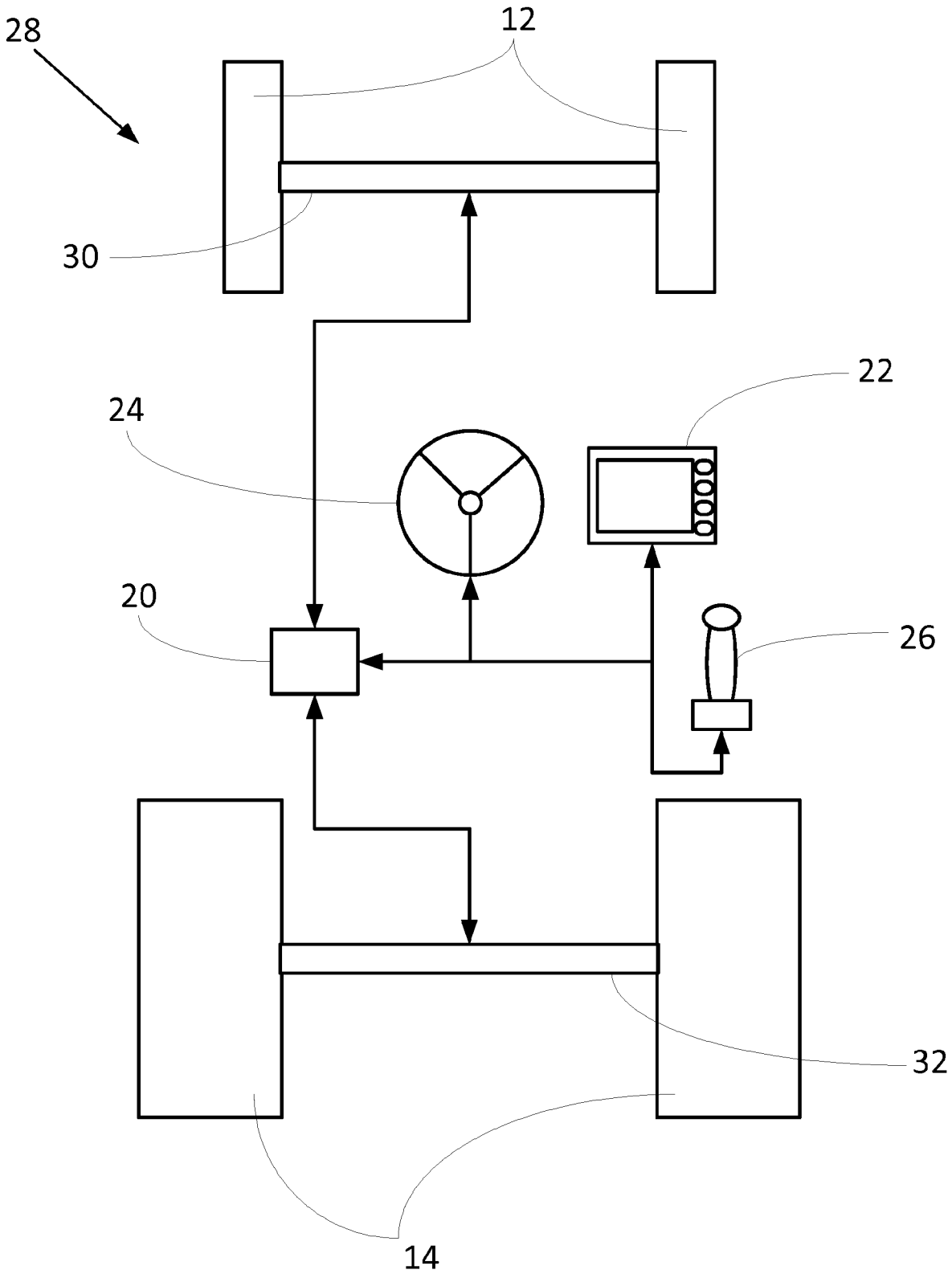

Fig. 2

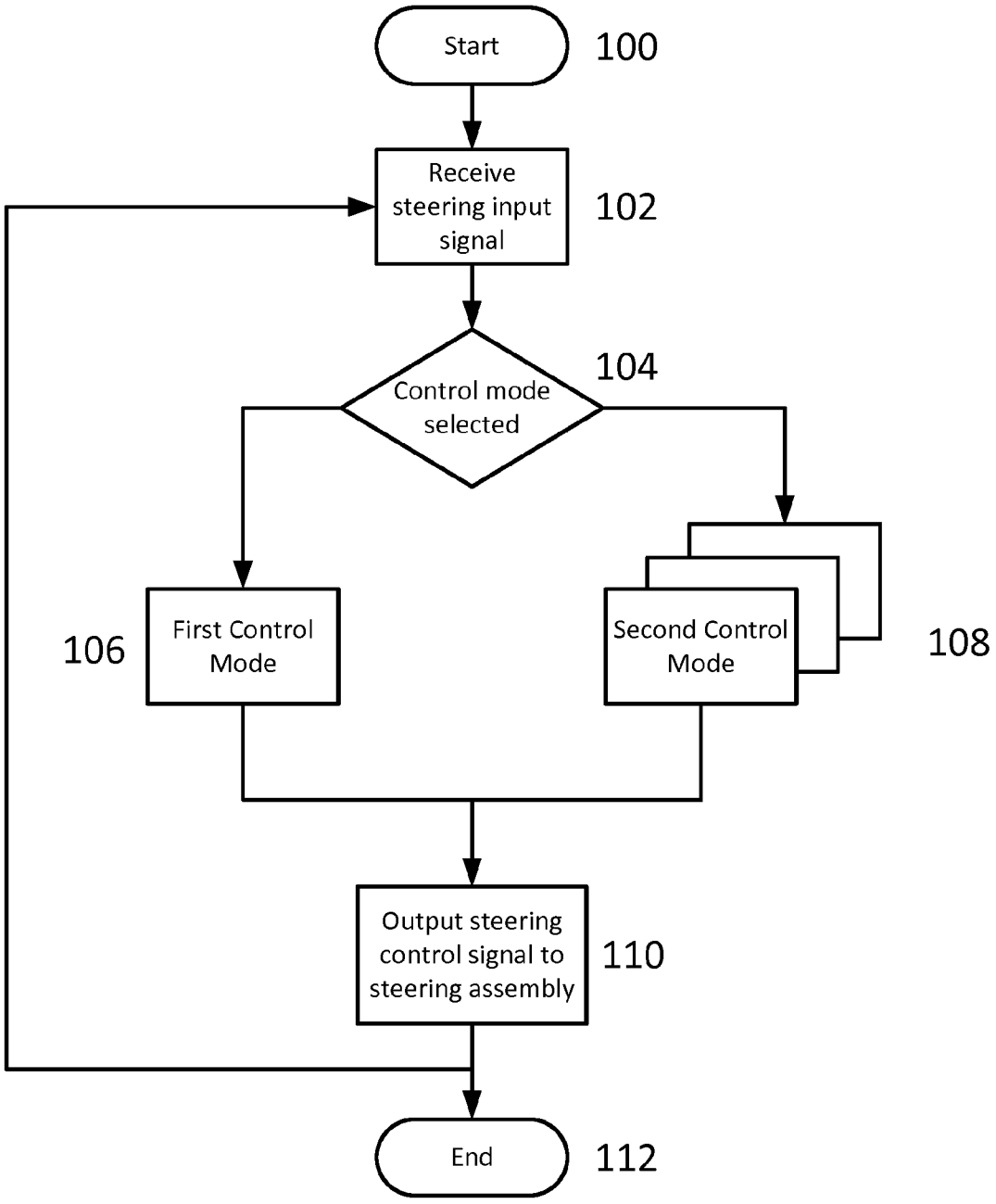
Start
100
Receive steering input signal
102
Control mode selected
104
First Control Mode
106
Second Control Mode
108
Output steering control signal to steering assembly
110
End
112

Fig. 3

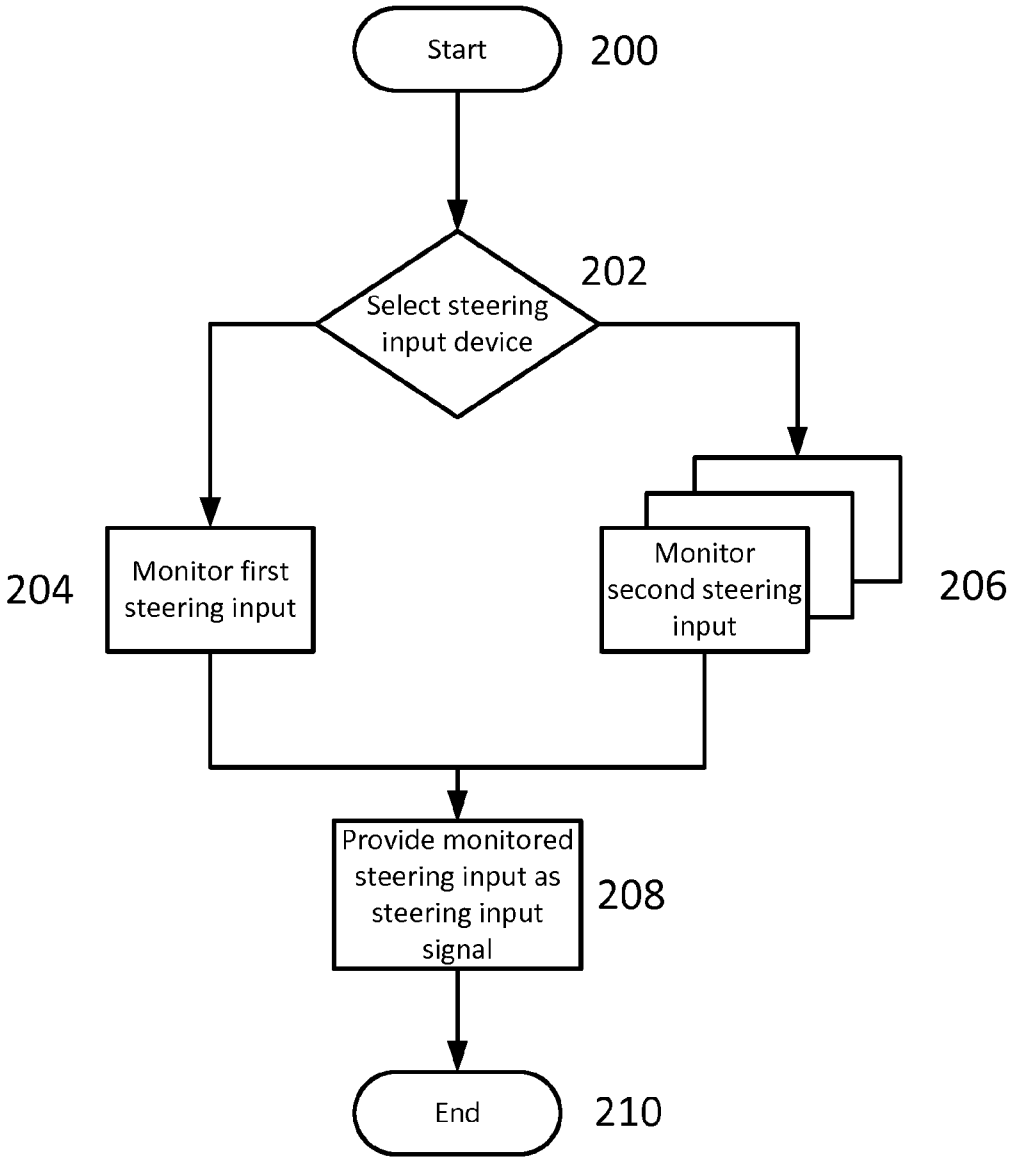
Start
200
Select steering input device
202
Monitor first steering input
204
Monitor second steering input
206
Provide monitored steering input as steering input signal
208
End
210

Fig. 4

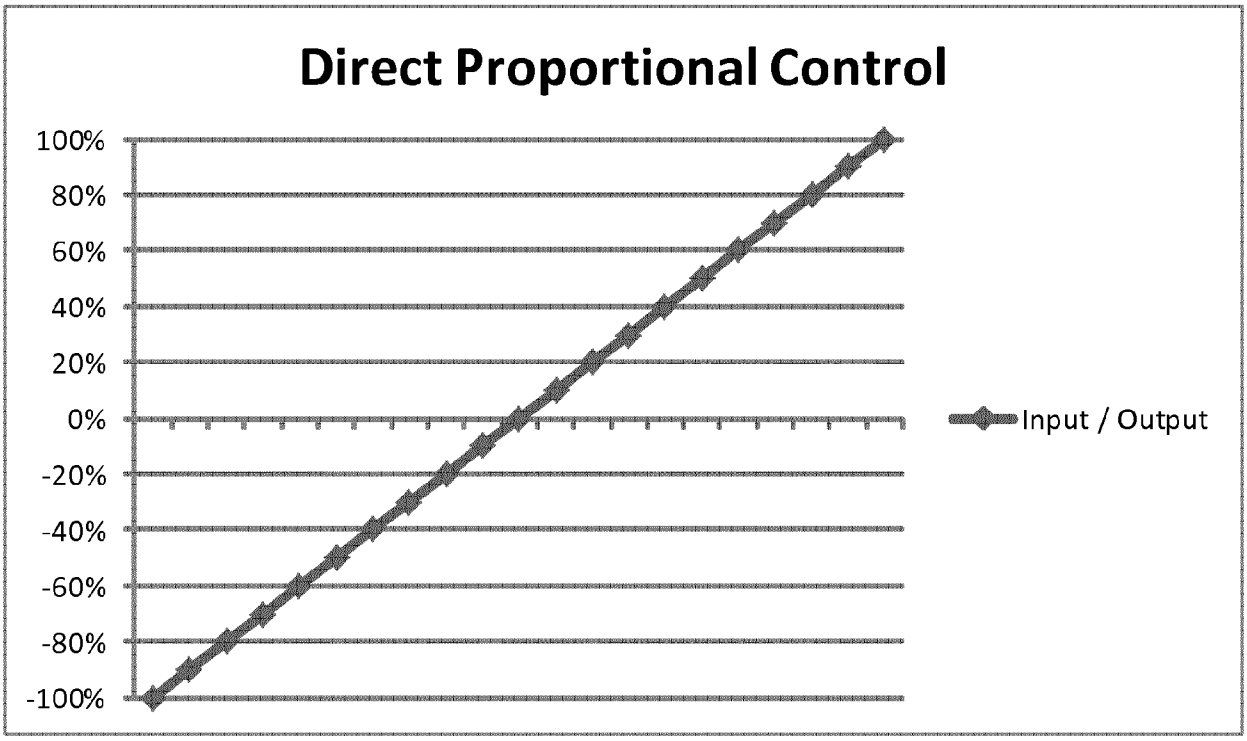
Direct Proportional Control
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
Input / Output

Fig. 5

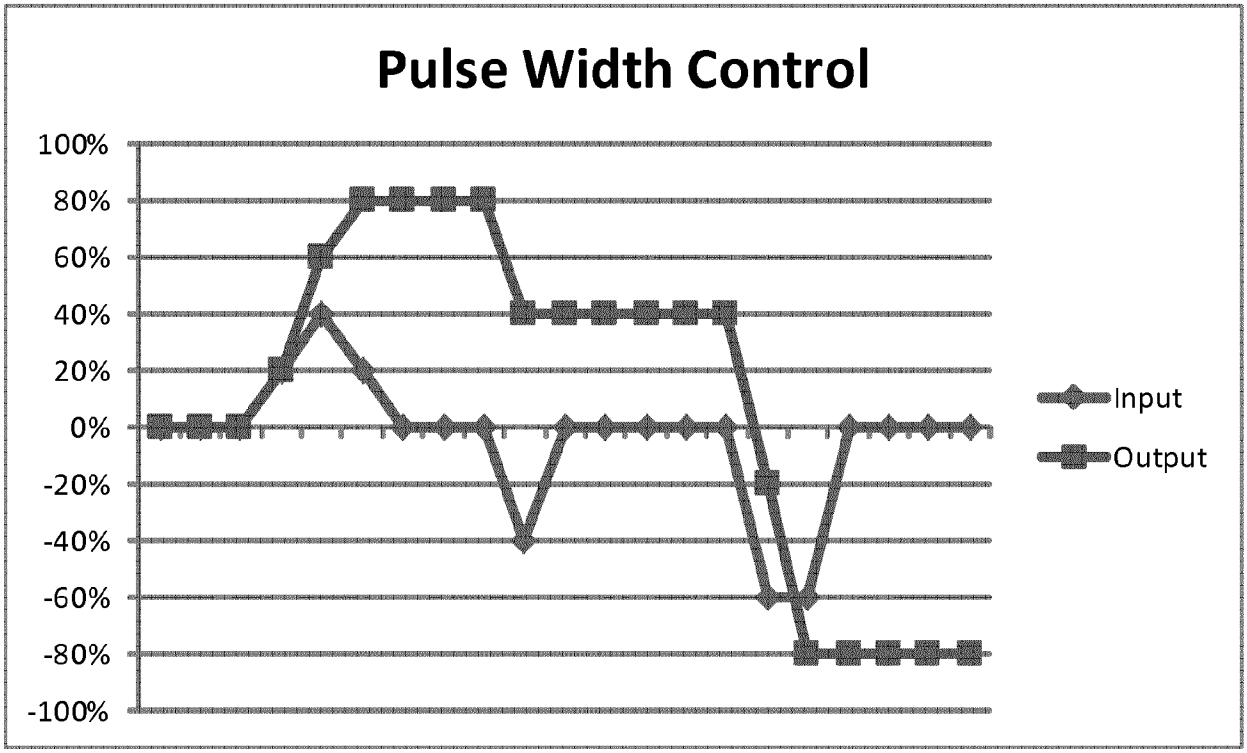
Pulse Width Control
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
Input
Output

Fig. 6

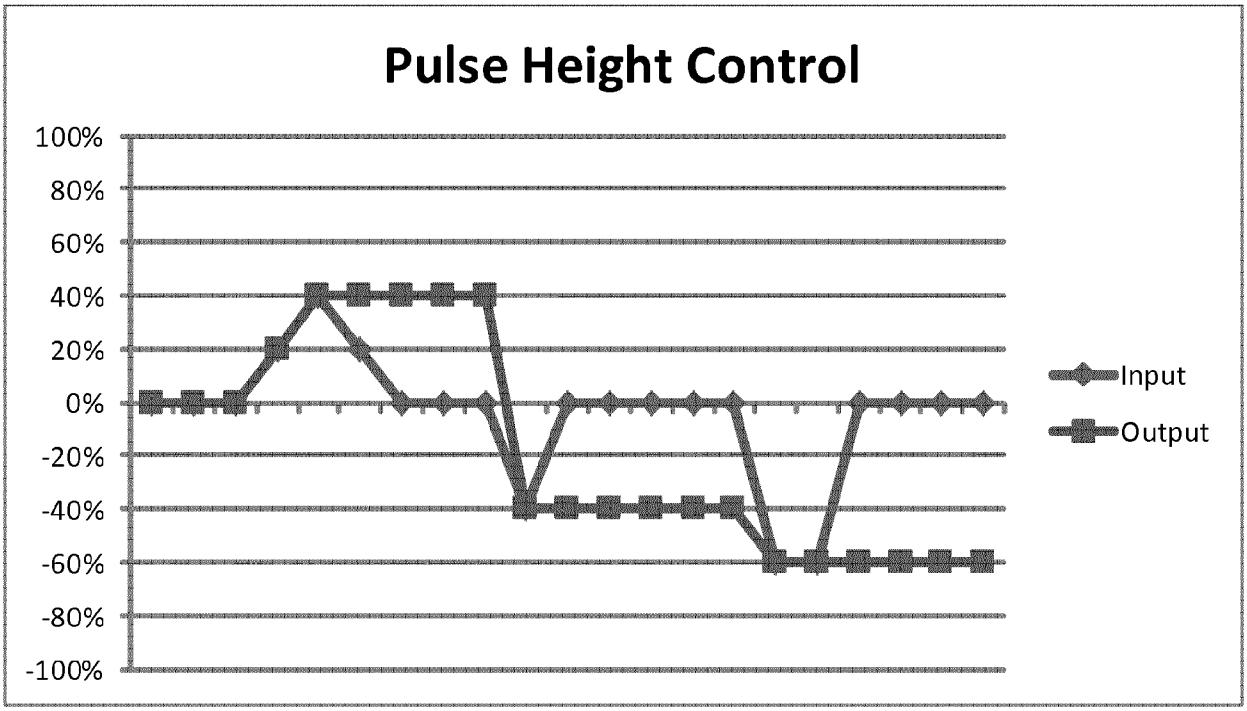
Pulse Height Control
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
Input
Output

Fig. 7

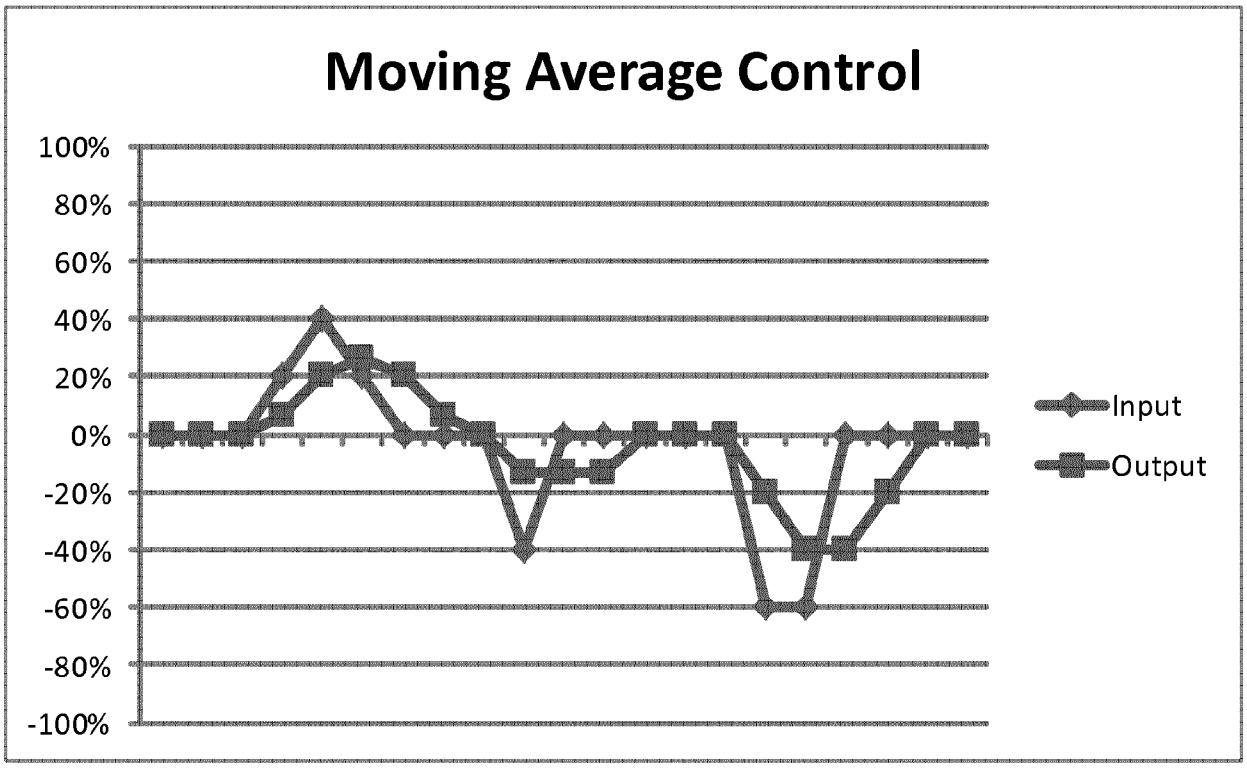
Moving Average Control
100%
80%
60%
40%
20%
0%
-20%
-40%
-60%
-80%
-100%
Input
Output

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057057

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D6/00 B62D1/22
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)
B62D

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/263338 A1 (TURNER MARCUS [GB] ET AL) 1 December 2005 (2005-12-01) paragraph [0019] - paragraph [0021]; figure 3	1-5,11, 12,19,20
X	WO 2013/034514 A1 (CNH ITALIA SPA [IT]; MORSELLI RICCARDO [IT]; CANUTO FRANCESCO [IT]; TU) 14 March 2013 (2013-03-14) figures 4,5a-8b page 16, line 25 - page 17, line 6 page 17, line 7 - line 11	1-20
X	US 2006/137931 A1 (BERG TORSTEN [DE] ET AL) 29 June 2006 (2006-06-29) paragraph [0035] - paragraph [0039]	1-20
A	DE 196 06 609 A1 (CLAAS OHG [DE]) 28 August 1997 (1997-08-28) column 2, line 60 - column 3, line 46	1,11,12, 20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 June 2017	27/06/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/057057

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