(54) Title: BACK-UP BRAKING SYSTEM AND METHOD FOR DRIVE-BY-WIRE VEHICLE

(57) Abstract: Back-up braking system (10) and method for reducing the velocity of a vehicle provided with an electronically controlled braking system (8, 13), and with a drive system comprising an engine (5) having a throttle control (11) for controlling the speed of the engine (5). The back-up braking system (10) is arranged to reduce the velocity of the vehicle using the throttle control (11) for a predetermined braking action. This may be accomplished by reducing the speed of the engine (5) after failure of the electronically controlled braking system (8, 13) or by clutching and shifting to a lower gear at reduced speed of the engine. The vehicle may be stopped by halting the combustion of the engine (5) at the lowest gear of the drive train (6) and at a predetermined engine speed.
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
Back-up braking system and method for drive-by-wire vehicle

The present system relates to a back-up braking system for use in a drive-by-wire vehicle, such as a passenger car. More specifically, the present invention relates to a back-up braking system for a vehicle, the vehicle being provided with an electronically controlled braking system and with a drive system comprising an engine having a throttle control for controlling the speed of the engine.

Such a system is known in a number of present and proposed vehicles having an electronically controlled braking system, such as the Electro Mechanical Brake Actuator produced by the applicant of the present invention.

In known systems usually a mechanical back-up braking system is provided, e.g. in the form of a mechanical parking brake. When a failure occurs of the electronically controlled braking system, the mechanical parking brake may be used to bring the vehicle to a controlled stop.

However, designers of fully electronic drive-by-wire vehicles are trying to find ways of removing the mechanical back-up braking system from the vehicle, as this saves cost, space and removes a mechanical system which itself may fail. When no mechanical back-up braking system is present, the electronically controlled braking system requires a redundant electrical system to enable a fail-safe operation of the vehicle.

The present invention, therefore, seeks to provide an improved back-up system for braking in a drive-by-wire car which back-up system is able to reduce the speed of a vehicle in case of a failure of the electronically controlled braking system, without the use of a mechanical back-up braking system, such as a parking brake.

According to the present invention, a back-up braking system is provided according to the preamble defined above, in which the back-up braking system is arranged to reduce the velocity of the vehicle using the throttle control for a predetermined braking action.

When the throttle control is used, the internal friction of the engine may be used to slow down the vehicle. This allows to reduce the speed of a vehicle, or even bring the vehicle to a complete stop after failure of the electronically controlled braking system. This can be accomplished when the engine of the vehicle is either a combustion
engine or an electrical engine. When the engine is an electrical engine, the vehicle may be brought to a complete stop by using the throttle control.

In an embodiment of the back-up braking system according to the present invention, a drive train is connected to the engine, the drive train being provided with a clutch and gear control, and the clutch and gear control is used to shift to a lower gear when the engine speed is below a predetermined value. This enables to use the internal friction of the engine in an effective manner. As is known, the internal friction of a combustion engine is higher when the engine speed (or RPM) is higher. Shifting to a lower gear will cause the engine to run at a higher speed, resulting in a more effective braking action.

In a further embodiment, the engine is a combustion engine and the back-up braking system is arranged to halt the combustion of the engine at the lowest gear of the drive train, and at a predetermined engine speed. This allows the vehicle having a combustion engine to be brought to a complete stop, e.g. by disconnecting the ignition supply or the fuel supply to the engine. This embodiment may also be used to provide an electronic parking brake for a drive-by-wire vehicle.

In a further embodiment, the vehicle is provided with two separate electrical power systems, the electronically controlled braking system being powered by a first electrical power system, and the throttle control being powered by a second electrical power system. In this embodiment, a fail-safe back-up braking system is also provided in the case of a failure of the first electrical power system supplying power to the electronically controlled braking system.

When a drive train is connected to the engine, the drive may be provided with a clutch and gear control, the clutch and gear control being powered by the second electrical power system. In this embodiment it is possible to use the throttle control and clutch and gear control in case of failure of the first electrical power system.

In a further embodiment, the engine is a combustion engine under control of a combustion control being powered by the second electrical power system and the back-up braking system is arranged to halt the combustion of the engine at the lowest gear of the drive train, and at a predetermined engine speed. This allows the vehicle with a combustion engine to come to a complete stop after failure of the first electrical power system. This embodiment may also be used to provide an electronic parking brake for a drive-by-wire vehicle having dual electrical power systems.
The first electrical power system may e.g. be a 42 volt power system and the second electrical power system may e.g. be a 12 volt power system.

In a further aspect, the present invention relates to a method for reducing the velocity of a vehicle provided with an engine for driving the vehicle and with an electronically controlled braking system comprising the step of reducing the speed of the engine after failure of the electronically controlled braking system. This method provides a fail-safe operation to reduce the speed of the vehicle, or to bring the vehicle to a complete stop, after failure of the electronically controlled braking system.

In a further embodiment of the present method, the vehicle is provided with a drive train connected to the engine, the drive train being provided with a clutch and gear control, the method comprising the further step of, at reduced speed of the engine, clutching and shifting to a lower gear. This embodiment allows to effectively use the higher friction of the engine at higher engine speeds to reduce the speed of the vehicle or to bring the vehicle to a complete stop.

When the engine is a combustion engine, the method may in a further embodiment comprise the further step of, at the lowest gear of the drive train, and at a predetermined engine speed, halting the combustion of the engine. This may be accomplished by switching off the ignition in a gasoline engine, or by switching off the fuel supply. When the engine is at low speed, providing no further braking action, the vehicle may be brought to a complete stop using this embodiment. In the lowest gear of the drive train, the vehicle velocity will be close to zero, and the vehicle may be stopped by halting the combustion of the engine without danger for the occupants or without possible damage to the vehicle.

The present invention will now be explained in further detail by using an exemplary embodiment of the present invention referring to the accompanying drawings, in which:

Fig. 1 shows a schematic diagram of a back-up braking system according to a first embodiment of the present invention; and

Fig. 2 shows a schematic diagram of a back-up braking system according to a second embodiment of the present invention.

A very schematic diagram of a vehicle is presented in Fig. 1, showing only the elements of the vehicle which are important in understanding the present invention. The vehicle is provided with an engine 5 for driving the vehicle. The vehicle is equipped
with wheels 7 which are driven by the engine 5. In case the engine 5 is an electrical engine, the wheels may be driven directly. In case the engine 5 is a combustion engine, the engine 5 drives the wheels 7 via a clutch and gearbox or an automatic gearbox, indicated by box 6 in Fig. 1, which enables the combustion engine 5 to be driven in its most effective speed range.

The vehicle in which the present invention is applied is equipped with an electronically controlled braking system 8 for performing a braking action on the wheels 7. The electronically controlled braking system may e.g. be an electromechanical brake actuator as produced by the applicant. The electronically controlled braking system 8 is controlled by brake control system 13 which monitors and controls the braking action of the electronically controlled braking system 8 and which supplies power to the braking system 8.

The engine 5 is controlled by an engine control system 11, which may comprise a throttle control for controlling the speed of the engine 5. Furthermore, when the engine 5 is a combustion engine, the engine control system 11 may further comprise a combustion system for controlling the fuel supply or ignition of the engine 5.

The gearbox and clutch or automatic gearbox 6 (in the case of a combustion engine 5) is controlled by a gear and clutch control system 12. The gear and clutch control system 12 is preferably operating in a drive-by-wire mode, such that the selection of gear and the clutch can be controlled electronically.

According to the present invention, a back-up braking system 10 is provided. The back-up braking system 10 is connected to the engine control system 11, the gear and clutch control system 12 and the electronic brake control system 13.

In the embodiment shown in Fig. 1, the vehicle is equipped with a dual power supply system. The electronic brake control system 13 (and via this the electronically controlled braking system 8) is supplied from a 42 volt power supply system 16. A 42 volt power supply system is usually chosen as the electronically controlled braking system 8 has a higher than usual power requirement, which in a normal vehicle power supply system would lead to excessive high currents. The other parts of the vehicle, especially the back-up braking system 10, engine control system 11 and gear and clutch control system 12, are supplied with power from the usual vehicle 12 volt power supply system 15.
The method of the present invention is preferably implemented in the back-up braking system 10. The back-up braking system 10 is connected to the electronic brake control system 13 and monitors the proper functioning of the electronically controlled braking system 8 and the status of the 42 volt power supply system 16.

Once a failure has been detected in either the 42 volt power supply system 16 or in the electronically controlled braking system 8, the back-up braking system 10 enables the speed of the vehicle to be reduced or the vehicle to be brought to a complete stop.

This is accomplished by supplying a control signal to the engine control system 11 to reduce the speed of the engine 5. The engine 5, which is still mechanically coupled to the wheels 7, has an internal friction, which will reduce the speed of the vehicle. When the engine 5 is an electric engine directly driving the wheels 7, the speed of the vehicle can be reduced substantially and the vehicle can even be brought to a complete stop.

When the engine 5 is a combustion engine, the braking action caused by the friction of the engine 5 will become very low below a certain engine speed. Once the speed of the engine 5 is below a predetermined value (at which the braking action caused by the friction of the engine 5 becomes low), the back-up braking system 10 supplies a signal to the gear and clutch control system 12 to shift to a lower gear. This causes the engine 5 to pick up speed again, enlarging the brake action again. This procedure is repeated until the lowest speed of the engine 5 has been selected.

Once the vehicle is at a very low speed, the back-up braking system 10 supplies a signal to the engine control system 11 to stop the engine 5 completely. As the engine 5 is still mechanically linked to the wheels 7, this will cause the vehicle to come to a complete stop. When the engine 5 is a diesel engine, this may be accomplished by cutting off the fuel supply to the engine 5. When the engine 5 is a gasoline engine, the engine 5 may be halted by interrupting the ignition of the engine 5.

The present invention thus provides an effective back-up braking system in case a failure occurs in the 42 volt power supply system 16, or in case a failure (electrical or mechanical) occurs in the electronically controlled braking system 8.

The back-up braking system 10 may also be used as an electronic parking brake. When the vehicle is being brought to a complete stop, the user of the vehicle may use a switch (not shown) to indicate that the electronic parking brake should be applied. The
back-up braking system 10 will then send a signal to the gear and clutch control system to engage a gear (preferably the lowest gear) and a signal to the engine control system 11 to keep the engine 5 inoperative. This causes a mechanical link to be present between the engine 5 and the wheels 7, providing an effective parking brake function.

Fig. 2 shows an alternative embodiment of the present invention. In this embodiment, the vehicle is equipped with only a single power supply system 15, which also supplies power to the electronic brake control system 13 (and to the electronically controlled braking system 8). In this case, the back-up braking system 10 will only be enabled when a failure is detected in the electronically controlled braking system 8, which may be a mechanical or electronic failure.
CLAIMS

1. Back-up braking system (10) for a vehicle, the vehicle being provided with an electronically controlled braking system (13), and with a drive system comprising an engine (5) having a throttle control (11) for controlling the speed of the engine (5), characterised in that the back-up braking system (10) is arranged to reduce the velocity of the vehicle using the throttle control (11) for a predetermined braking action.

2. Back-up braking system according to claim 1, in which a drive train (6) is connected to the engine (5), the drive train (6) being provided with a clutch and gear control (12), the back-up braking system (10) being arranged to use the clutch and gear control (12) to shift to a lower gear when the engine speed is below a predetermined value.

3. Back-up braking system according to claim 1 or 2, in which the engine (5) is a combustion engine and the back-up braking system (10) is arranged to halt the combustion of the engine (5) at the lowest gear of the drive train (6), and at a predetermined engine speed.

4. Back-up braking system according to claim 1, in which the vehicle is provided with two separate electrical power systems (15, 16), the electronically controlled braking system (13) being powered by a first electrical power system (16), and the throttle control (11) being powered by a second electrical power system (15).

5. Back-up braking system according to claim 4, in which a drive train (6) is connected to the engine (5), the drive train (6) being provided with a clutch and gear control (12), the clutch and gear control (12) being used to shift to a lower gear when the engine speed is below a predetermined value, the clutch and gear control (12) being powered by the second electrical power system (15).

6. Back-up braking system according to claim 4 or 5, in which the engine (5) is a combustion engine under control of a combustion control (11) being powered by the second electrical power system (15) and the back-up braking system (10) is arranged to
halt the combustion of the engine (5) at the lowest gear of the drive train (6), and at a predetermined engine speed.

7. Back-up braking system according to claim 4, 5 or 6, in which the first electrical power system (16) is a 42 volt power system.

8. Back-up braking system according to claim 4, 5, 6 or 7, in which the second electrical power system (15) is a 12 volt power system.

9. Method for reducing the velocity of a vehicle provided with an engine (5) for driving the vehicle and with an electronically controlled braking system (8, 13) comprising the step of
   - reducing the speed of the engine (5) after failure of the electronically controlled braking system (8, 13).

10. Method according to claim 9, in which the vehicle is provided with a drive train (6) connected to the engine (5), the drive train (6) being provided with a clutch and gear control (12), the method comprising the further step of
    - at reduced speed of the engine (5), clutching and shifting to a lower gear.

11. Method according to claim 9 or 10, in which the engine (5) is a combustion engine and the method comprises the further step of
    at the lowest gear of the drive train (6), and at a predetermined engine speed, halting the combustion of the engine (5).

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Fig 1
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

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<th>B60T8/00</th>
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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)

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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 practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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* Further documents are listed in the continuation of box C.
X Patent family members are listed in annex.

**Date of the actual completion of the international search**

21 February 2002

**Date of mailing of the international search report**

28/02/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk
Tel: (+31-70) 340-2040, Tx: 31 651 epc nl, Fax: (+31-70) 340-5016

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Bufacchi, B
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