



(51) International Patent Classification:

B60L 7/10 (2006.01) *B60L 7/26* (2006.01)
B60L 7/24 (2006.01) *B60L 15/20* (2006.01)

(21) International Application Number:

PCT/EP2024/066688

(22) International Filing Date:

14 June 2024 (14.06.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

102023000012318 15 June 2023 (15.06.2023) IT

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(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG,
KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,
MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA,
NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO,
RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(54) Title: VEHICLE AND METHOD FOR SINGLE PEDAL DRIVING

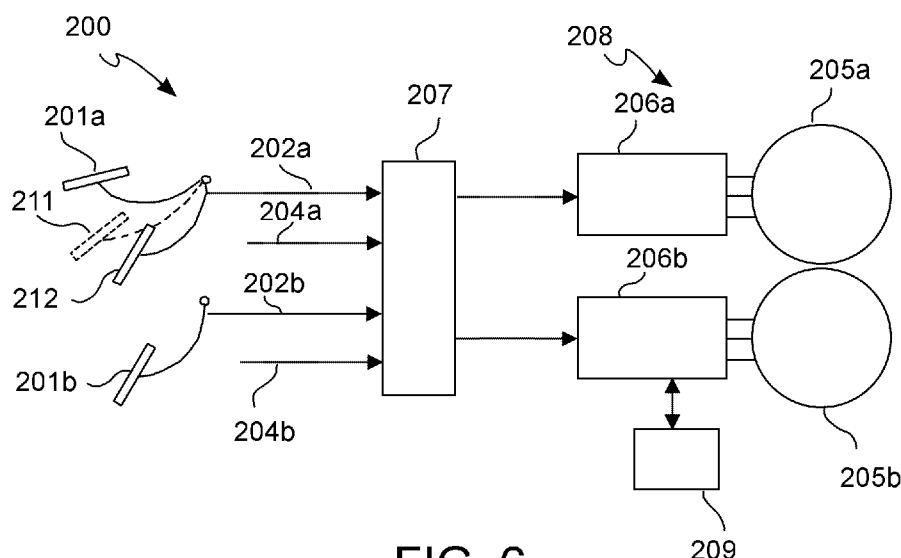


FIG. 6

(57) Abstract: The present invention is related to a vehicle, in particular an electric vehicle comprising an electric powertrain and at least one, preferably electric, energy storage unit, comprising a one-pedal driving system, comprising at least one vehicle throttle control, for controlling a throttle power and at least a part of a braking power of the vehicle, at least one braking system, configured for providing a braking power to the vehicle, wherein said braking power is at least partially based on a braking power demand signal, wherein said braking power demand signal is determined based on an integral of at least one measured variable of the vehicle throttle control. The invention is further related to a method for single throttle driving of a vehicle, and a regenerative braking system to achieve an extended range by minimizing energy consumption, or minimize tyre wear or minimize brake wear or minimize particle emission from tyre or minimize particle emission from brake or any combination thereof.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

Vehicle and method for single pedal driving

The present invention is related to a vehicle comprising a one-pedal driving system, a single pedal throttle control braking system for use in a vehicle, and a method for
5 single pedal driving.

Regeneration of energy within vehicles, such as automobiles and/or motorbikes and/or autonomous robot taxis and/or scooters and/or electric vertical take-off and landing vehicles (VTOLs) and/or helicopters and/or electric bicycles and/or more-
10 electric planes is one of the technologies that increases range and minimizes energy waist. Energy waist in this respect is considered as the energy that can be captured from a moving body, i.e., vehicle, due to deceleration of that body, in vehicles this is the so-called brake energy, that is normally transformed into heat, instead of useful electrical energy. Every accelerating vehicle needs to be
15 decelerated at a certain point in time, regenerative braking is an energy recovery mechanism converts kinetic energy into, preferably electrical, usable energy that can be used immediately and/or stored in an energy storage unit. In this invention an energy storage unit is determined to be a means to store, for example electrical, energy for a long time or temporarily, examples but not limited to are a battery
20 and/or a capacitor and/or a supercapacitor and/or a rotating inertia directly connected to a generator and/or a latching circuit and/or rotating flywheel and/or added power train inertia. Similar to many sophisticated electrical systems, energy efficiency in both acceleration as deceleration of vehicles should be carefully managed and maximized. In all electric-powertrain vehicles heat, due to the
25 inefficiencies in the conversion of energies, is something that need careful consideration. Until now most electric-powertrain vehicles still require a friction brake that is used to convert kinetic energy into heat and not in automotive energy-storage systems. A regenerative system adds an opposing torque to the direction of wheel travel, or inertia, to an axle during braking and transforms the kinetic
30 deceleration energy into electrical energy. Although a clutch could also be installed to such an added inertia to provide at least one braking energy burst. In general, the most important aspect is to provide braking in all events and in such a manner that the driver trusts the braking action that is initiated.

In most present day vehicles, solely a brake-pad assembly, mounted concentrically with the hub of a ground-engaging wheel, is actuated upon braking to supply frictional engagement between the hub and clutch mechanism, while applying a decelerating torque to the wheel. Optionally, an electrical generator, which may also act as a motor, could be mounted concentrically with the hub of a ground-engaging wheel, and/or via a trans-axle and/or differential and/or frictional engagement using a clutch mechanism, and can be actuated upon braking to supply an opposing torque, either in a burst, peaking bursts and/or continuous manner, while applying a decelerating torque to the wheel and/or wheels. Such a system is able to ensure braking is always present and/or accumulates most of the kinetic energy over a braking event and is activated by a throttle and/or braking and/or combination. Vehicles with brakes that are augmented with electric machines in the powertrain can use this machine as a motor when accelerating and as a generator when deceleration and can even achieve regenerative braking, where the output of the electrical machine is supplying an electrical storage and/or brake resistor and/or frictional heat and/or mis-commutation of the electric motor to momentarily decrease its efficiency to a mere zero percent and/or combination, for example when the energy storage is at full capacity. Such regenerative braking systems may allow for single pedal driving. That is, when a driver releases its foot from the throttle, the electric motor may act as a brake to recuperate kinetic energy in an attempt to increase the range of the battery vehicle. Electric-powertrain vehicles offer a solution for reducing the environmental impact of driving and will transform automotive mobility into a more sustainable mode of transportation. Energy-storage systems are essential for electric-powertrain vehicles, such as hybrid electric vehicles, plug-in hybrid electric vehicles, and all-electric vehicles. Since recuperation of energy may allow for increasing electric driving range, this is an important aspect of the electric powertrain vehicles to manage and to optimize.

Two significant downsides however remain unsolved for single pedal driving. First of all, the regenerative braking that is initiated by releasing the foot from the throttle is not natural. That is, the user is unable to forecast or predict the braking torque that is to be applied. This is mostly determined by a vehicle control unit based on data such as a speed of the vehicle, a proximity of certain objects detected by a camera, or the like. This causes a lot of waste of usable energy since this lack of a

natural or predictive feeling may urge a user to apply a mechanical brake instead. Secondly, the available systems are only usable for battery electric vehicles, whereas single pedal driving may be more widely applicable, for example in the throttle handle of motorbikes and/or electric bicycles and/or scooters and/or wheel
5 chairs and/or robot taxi's and/or even in vehicle that are also equipped with an active electromagnetic vehicle suspension system.

It is a first goal of the present invention to provide for a single pedal driving system that allows for a more reliable and more predictable braking experience.
10
It is a second goal of the present invention to provide for a more widely applicable single pedal driving system.

15 The present invention thereto provides a vehicle, in particular an electric vehicle according to claim 1. The braking power demand signal may, at least partially, also be determined based on a derivate of at least one measured variable of the vehicle throttle control.

20 The vehicle according to the present invention allows to use a vehicle throttle control, such as a throttle pedal, for applying a braking power. Said braking power being at least partially based on a braking power demand signal. The braking power demand signal may for example comprise a braking magnitude, such as a braking torque. By using an integral, and in further embodiment also a derivative, of
25 a measured variable of the vehicle throttle control, a more intuitive braking signal, and hence braking power may be generated. This allows the driver to apply a braking power through the vehicle throttle control in an intuitive manner, hence allowing the driver to be able to predict the braking power. This allows for an increased safety, in particular by increase of trust of the driver in the braking action
30 that is initiated. The measured variable is in particular a variable related to the vehicle throttle control. Hence, controlling the vehicle throttle control by a driver, such as by means of the foot of a driver, said variable changes accordingly. Preferably, the at least one integral, and optionally also a derivative, of the at least one measured variable is used in addition to a vehicle throttle position, such as a
35 pedal position. This may allow for obtaining a better braking power demand signal,

which allows to apply a more intuitive or predictable braking power to at least one wheel.

A distinction should be made in respect of the present invention. The vehicle
5 throttle control must be considered a user input that allows for controlling a vehicle acceleration. In a regular car, the vehicle throttle control may be known as a throttle pedal. The present invention is related to vehicle throttle controls which are configured to generate a braking power demand signal, either directly or indirectly. Hence, the invention is not related to a regular vehicle which uses a distinct braking
10 pedal to generate said braking power demand signal. That is, the vehicle throttle control has a multi-purpose, in that it controls both the vehicle acceleration as well as the vehicle deceleration. The vehicle throttle control may be a mechanical system, e.g., coupling the throttle via one or more links or joints to a throttle body. Alternatively, a cable, or cableless equivalent, may be used for coupling of the
15 vehicle throttle to a throttle body. Lastly, it is conceivable the throttle control is a fully electronic system, connected via a wire to the throttle body. Preferably, the latter system comprises an electronic control module for generating a signal corresponding to a specific driver throttle control movement. The one-pedal driving system may be understood as the vehicle comprising a vehicle throttle control
20 which not only controls the throttle power of the vehicle, but additionally controls, directly or indirectly, at least a part of the braking power of the vehicle. However, the invention is not limited per se to merely one-pedal operation of the vehicle. That is, it is conceivable the vehicle throttle control according to the invention is applied in combination with a conventional brake control, and/or in combination with one or
25 more additional vehicle throttle controls. Therefore, one-pedal in this respect is to be understood broadly, relating to the ability that a single pedal, i.e., throttle control, is configured to both control the throttle power, vehicle acceleration, and braking power, vehicle deceleration, of the vehicle as such. Thus, not excluding
embodiments which comprise multiple throttle controls.

30

The present invention provides not only the driver with a single vehicle throttle control, but that the first (and/or second and/or any consecutive, if applied) differential or integral of the change in the measured variable (e.g., throttle position) may be utilized to control the vehicles variation in speed. Optionally, also a reset of
35 the throttle position for achieving coasting is possible taking into account tyre-road

friction and/or road slope and/or position of the vehicle with respect to the rest of traffic and/or weather. That is, any environmental influences, internal or external to the vehicle states that should be accounted for. In one embodiment it may be conceivable to control of the complete vehicle with a single vehicle throttle control.

5 For example, by pressing a pedal all the way to the bottom the vehicle may be 'started'. In case of an electric or hybrid electric vehicle, 'Starting' may be understood as 'activating'. By completely removing the foot from the vehicle throttle control maximum braking of the regenerative motor, so-called generator, and/or friction brake may be activated depending vehicle status. Or 'activation' can be
10 achieved by a sequence of single throttle pressing and releasing events. If two throttles are utilized, this would also allow for steering as is now the case in a taxiing plane.

This might be counter-intuitive, therefore it is also conceivable that pressing the
15 one-pedal down and releasing it activates the vehicle and when the throttle position has a positive integral in a relatively fast manner this set a zero speed coasting position from which an absolute positive position change will mean acceleration and a negative position change will decelerate the vehicle. This 'coasting' position, actually also zero torque at zero position is something that can be provided in a
20 mechanical manner, but also by utilizing not only a position sensor on the throttle control, but also an actuator according to the invention.

In another embodiment, the single throttle may be programmed in for example a logarithmic manner to make it less or more sensitive to driver input variations. This
25 could also be a learning process, where the throttle control is educated, for example, using artificial intelligence and/or machine learning and/or genetic algorithm, to react in a less or more responsive manner to the driver. For example, somebody with Parkinson disease, which will move the foot up and down in a less controlled manner, and the educated and/or intelligent one-pedal will react less to
30 variations of the driver.

Preferably, the vehicle, in particular the at least one vehicle throttle control, comprises at least one sensor for measuring said integral, and in a further embodiment also a derivative, of the at least one measured variable. This may
35 allow for directly obtaining the value corresponding to said integral, and optionally

also said derivative, of the measured variable. Using the integral, and optionally also the derivative, value allows for eliminating creep from the system. Creep is intended to mask the free-play in the, typically linear, pedal characteristic. However, in general creep is something that is not desired since it may be unpredictable.

- 5 However, the free-play in the pedal characteristic is needed in order to obtain motoring and/or regenerative inverter input signals. The present invention allows for usage of the integral value, and optionally also the derivative, to generate the vehicle braking demand signal. Even after very limited vehicle throttle control changes, the motoring and/or regenerative input signals may be generated.
- 10 Preferably the at least one sensor is a gyro and/or a gps-sensor and/or a rotational sensor and/or position sensor and/or visual sensor and/or a throttle and/or driver foot camera. Preferably, in case of a rotational sensor, said sensor is configured for measuring a rotational position, a rotational speed, a rotational acceleration, a rotational jerk. The visual sensor may for example be composed by a camera which
- 15 detects a variable of the vehicle throttle control. For example the camera may detect various position of a throttle control, preferably using said positions to determine a vehicle throttle control speed. Said sensor may be provided onto the vehicle throttle control. For example, the rotational sensor may be incorporated internally in a pedal. It is also conceivable, for example in case of a visual sensor,
- 20 to apply the sensor at a distance of the vehicle throttle control. Instead of utilizing a throttle control position as a torque setpoint, the vehicle throttle control uses for example a vehicle throttle control velocity as a torque setpoint. The vehicle throttle control position is not preferred since it dates back from the internal combustion vehicles, where throttle control positions correspond to a valve opening and
- 25 closing. However, in particular in case of an electric vehicle, no such valves are present and the electric powertrains may require a torque as an input. Therefore, using an integral, and optionally also a derivative, of a measured variable of the vehicle throttle control may allow for more accurately providing a traction and/or braking force based on a traction and/or braking power demand signal. The at least
- 30 one sensor preferably directly obtains the value of the integral and optionally also the derivative, of the at least one measured value. That is, should the measured value be a position, the sensor obtains a value of the absement and/or velocity of the vehicle throttle control. By directly obtaining the absement (integral of the position) and optionally also the velocity (derivative of position) an increased
- 35 accuracy may be obtained. Potentially, the velocity may be obtained by various

measurements over time of a throttle control position. A position may be measured according to for example an x-y-z coordinate scheme. It is possible to utilize the derivative of the position in at least one coordinate, or use the derivative in one or more coordinates. By using the derivative in all directions, the magnitude may be determined, which may provide for additional information. However, obtaining the velocity this way potentially comes at the cost of increased noise in the signal which is not wanted. Additionally, this way of computing velocity may yield an overshoot in the obtained value. Especially in case of further derivatives or integral values, this overshoot quickly disturbs the signal making the signal unusable, contrary to directly using a sensor to obtain the value.

According to a preferred embodiment the vehicle further comprises at least one control unit, wherein the control unit is configured for determining, based on the integral, and optionally also the derivative, of the at least one measured variable, a braking power demand signal, and instructing, based on the braking power demand signal, the braking system, preferably a regenerative braking system. The control unit may for example be a vehicle control unit, or may be part of an inverter, or may be an entirely separate control unit dedicated for the single pedal drive of the vehicle and/or a combination. The control unit of the vehicle may receive the integral, and optionally also the derivative, of the at least one measured variable directly, or may determine such based on the sensor data.

Preferably, the at least one control unit is configured for applying a filter. In particular a jerk oscillation filter which allows for preventing jerk oscillations of the vehicle, as well as torsional oscillations in the drivetrain of said vehicle. That is, a driver may not have a fully steady control of the vehicle throttle control. Minor variations in the vehicle throttle control output may introduce such oscillations. In particular when the vehicle throttle control is switching between a decelerating output, in particular braking output, and an accelerating output. To this end, the filter utilized by the control unit may smoothen the signal. That is, mostly these minor fluctuations between decelerating output and accelerating output refer to the driver intending to maintain a steady position. The control unit may either directly instruct the braking system, or may for example instruct an inverter in case of a regenerative braking system. Said inverter may receive the braking demand signal and apply a corresponding braking torque via the motor. The filter may also be a

learning process, where the filter is educated, for example, using artificial intelligence and/or machine learning and/or genetic algorithm, to react in a less or more responsive manner to the an accelerating and/or decelerating request initiated by a driver through the vehicle throttle control.

5

Preferably, the control unit is further configured for receiving at least one drivetrain output variable, preferably wherein the braking power demand signal is determined based on the integral, and optionally also the derivative, of the at least one measured variable of the vehicle throttle control and the at least one drivetrain
10 output variable. Hence, said drivetrain output variable may be understood as a secondary variable, in addition to the at integral, and optionally also the derivative, of the measured variable of the vehicle throttle control. It is conceivable the drivetrain output variable is chosen from the group comprising: a state of charge of at least one energy storage unit, in particular an electric energy storage unit such
15 as a battery, a vehicle speed, a vehicle current gear, a vehicle battery, a motor temperature, a vehicle acceleration, and/or a vehicle steering wheel orientation. In addition to a drivetrain output variable, the braking power demand signal and/or an acceleration and/or deceleration signal may be determined based on the integral, and optionally also the derivative, of the at least one measured variable of the
20 vehicle throttle control and at least one drivetrain output variable or at least one external output variable. The external output variable is preferably chosen from the group comprising: a vehicle camera, such as a front and/or rear and/or side camera, a throttle and/or driver foot camera, a vehicle positioning sensor, an ambient temperature sensor, and/or at least one parking sensor, and/or a wheel
25 speed sensor, and/or a wheel torque sensor, and/or a vehicle speed sensor, and/or a moisture sensor and/or a radar sensor, and/or a lidar sensor, such as for detecting, for example, ambient conditions like rain or cold and/or mist and/or surfaces of varying friction coefficients and/or obstacles and/or cornering and/or banked road and/or road damage and/or speed ramps. Such an external output
30 variable may be used in certain conditions to for example limit the throttle demand or the braking demand, such as in case of a near obstacle. However, in emergency situations said outside output variable may be used to remove a throttle and/or braking demand, for example if a vehicle is detected from a front and/or rear side of the vehicle which is to make a collision with the vehicle, in particular in the direction
35 of travel. By removing a throttle or braking demand in such a condition, the vehicle

- may roll and under a rear impact collision the movement induced by impact may absorb some of the collision energy, contrary to when the brakes are applied. The at least one drivetrain output variable may be used to adapt a braking power demand signal at least partially to a current drivetrain status. That is, if a braking
- 5 power demand signal comprises an instruction to apply a large braking torque, but a motor temperature, or state of charge of a battery and/or modular batteries and/or multiple different chemistry batteries is too high, the control unit may determine to allocate the braking demand towards a mechanical brake solely.
- 10 According to a preferred embodiment, the control unit is further configured for validating the determined braking demand signal, in particular based on a secondary variable if applied and/or a drivetrain output variable. If for example a user fully releases a vehicle throttle control, this would according to the prior art always yield a maximum, or at least pre-set level of, or pre-set lookup table of
- 15 throttle position based, regenerative braking force. However, releasing the vehicle throttle control does not necessarily reflect the wish of a driver to apply significant braking force. For example, on a highway, where it is calm, there is no urgent need to apply significant braking force upon release of the vehicle throttle control. Hence, in such scenario the control unit validates the braking power demand signal based
- 20 on, e.g., a camera in the front, and the current speed of the vehicle, to determine no urgent need for braking is present. In such a case, the control unit may revert a warning signal to the driver that a braking torque is about to be applied. This warning may provide the driver to act and reinstate the position of the vehicle throttle control to prevent the braking action. Yet, alternative validations are also
- 25 conceivable as long as the trust of the driver remains that in case braking is requested, it will and can be provided for.

Preferably, when the vehicle is on cruise control, that remains the vehicle speed to a pre-set velocity, the vehicle throttle control may completely respond as a brake

30 pedal. Following such a braking event, that is when the vehicle throttle control pressed either to the extreme position and/or a half way position, the single throttle again starts to behave as mentioned before, for example, with a certain position in which cruising will be achieved.

Preferably, the control unit is configured for determining an available regenerative braking power, and comparing the braking power demand signal with the available regenerative braking power, and preferably allocate the braking power demand signal to a regenerative braking system if the amount of available regenerative braking power is larger than the braking power request of the braking power demand signal, or allocate a part, preferably a maximum part, of the braking power request of the braking power demand signal to said regenerative braking system and allocate a remainder of said braking power request of the braking power demand signal to at least one alternative braking element if the amount of available regenerative braking power is smaller than the braking power request of the braking power demand signal. This embodiment is in particular beneficial in combination with the regenerative braking system according to the present invention. It is conceivable that it is not the control unit as such which determines the available regenerative braking power. It should be understood that determining the available regenerative braking power includes receiving, such as from an electrical energy storage unit, such as a battery, an available regenerative braking power. By comparing the available regenerative braking power with a requested braking power governed by the braking power demand signal, optimal use can be made of the regenerative braking system. That is, the maximum amount of kinetic energy can be recovered. An alternative braking element may for example be a friction brake, however the alternative brake demand may also be stored in the form of heat, instead of electric energy. This allows to utilize the energy for which no regenerative braking power is available in the form of heat, for example in an air conditioning system.

According to a preferred embodiment the control unit is further configured to adjust a magnitude of the braking power corresponding to the braking power demand signal, preferably based on artificial intelligence by storing the integral, and optionally also the derivative, values of the measured variable of the vehicle throttle control of historic occurrences. This embodiment allows for smart braking strategies. It is conceivable a driver is unable to accurately predict the required braking point, such as upon arriving at a sharp turn. This may cause that the vehicle has slowed down too much, too quickly. Slowing down fast provides a shorter timeframe for regenerating energy, which may yield a spike of high density energy, of which a battery can only accumulate a maximum amount, based on the

charging rate available. By allowing the control unit to adapt the braking power demand signal, the right deceleration may be obtained, which may yield in a more balanced energy utilization over time. Hence, allowing the battery to charge at its maximum capacity for a longer amount of time, thus regenerating more energy.

5 This example is merely illustrative, and different scenarios may involve similar benefits. In the longer term, sufficient data may be available to determine a user pattern, corresponding to one of the specific users of the vehicle. Based on this user pattern, the control unit may apply a specific strategy to determine the braking power demand signal based on the integral, and optionally also the derivative, of
10 the measured variable.

It is conceivable that the control unit is further configured for, preferably continuously, determining an instantaneously available braking power, preferably based on the integral of the at least one measured variable of the vehicle throttle
15 control. If, for example, the measured variable is a position of the vehicle throttle control, its integral may yield a sum of available braking demand. That is, should the throttle control be fully released, the potential energy, mostly depending on a current vehicle speed, may become available for regeneration. By determining the available braking power, the vehicle control unit may use the data for predicting a
20 vehicle range.

According to a preferred embodiment, the vehicle throttle control is at least moveable in a first direction, and at least one second direction, wherein the first and second direction are mutually different, and preferably wherein the vehicle braking
25 demand signal is determined based on the integral, and optionally also the derivative, of the at least one measured variable of the vehicle throttle control in one of the first and/or second direction, preferably wherein the other direction controls the vehicle throttle demand. It is preferred that the vehicle throttle control is moveable in two directions, such that each direction may represent one of a
30 braking control and a throttle control. In particular, wherein a zero-position separates the throttle demand and the braking demand of the vehicle throttle control, wherein a control unit is configured for dynamically varying the zero-position. A zero-position may be understood as a throttle control position which separates a throttle demand and a braking demand. Hence moving the throttle
35 control in a first direction away from the zero-position may for instance initiate a

throttle demand, wherein moving in an opposite direction away from the zero-position may provide a braking demand. Control unit may reprogram the vehicle throttle control such that said zero-position is dynamically shifted over the range of movement of the throttle control. It may be conceivable that a user feedback is

5 provided once the vehicle throttle control is at its zero-position. Such user feedback thus indicates a specific position of the throttle control. The user feedback relating to the throttle control zero-position may for example be provided by means of a vibration. Ideally said vibration is noticeable through the vehicle throttle control. Alternatively, said feedback may be rendered via other means, such as via a

10 steering wheel and/or a screen and/or audible. Dynamic alteration of the zero-position provides flexibility in terms of the sensitivity of both the throttle demand as well as the braking demand. In particular, a larger possible movement in the braking direction of the vehicle throttle control allows a driver to apply a braking demand more subtly. This may prevent abrupt application of larger braking powers

15 if only a small movement is available. Intelligent vehicle pedal control is a new development trend of vehicle intelligence, an important application of which is the single pedal control being the driving and braking inputs for energy management of a battery electric vehicle. Based on the dynamic zero position that is a variable (e.g., pedal angle) depicting the direction switch point during pedal rotation, single

20 pedal control can operate the driving and the braking of a (battery electric) vehicle. Preferably the vehicle, in particular the vehicle throttle control, comprises at least one feedback actuator, directly or indirectly connected to the vehicle throttle control, for providing a user feedback and/or a user reference position through the at least on vehicle throttle control. Preferably, wherein the feedback actuator is configured

25 to provide a feedback to the user when the vehicle throttle control passes a vehicle throttle control mid position and/or, optionally dynamic, zero-position. The feedback may allow the user to experience a more natural experience, in particular in applying a braking demand through the vehicle throttle control. That is, intuitively a driver is accustomed to feeling a forced feedback in a braking pedal. Pressing the

30 braking pedal harder means a higher feedback force through the driver's feet is noticeable. The feedback actuator may be arranged to provide similar feedback in the throttle pedal. Especially during lifting of the pedal, and thereby generating a braking power demand, the actuator may provide for a feedback force urging the driver the feel the same as pressing a conventional brake pedal. Similar feedback

35 is also conceivable when the vehicle throttle control is not a pedal, but a different

element. By providing such a feedback force, the experience of the throttle control may be more intuitive compared to merely releasing the vehicle throttle control without receiving any form of feedback regarding the braking demand that is about to be applied.

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Another form of feedback that may be rendered by such an actuator to learn a driver to drive as energy efficient as possible. To this end the actuator may position the vehicle throttle pedal in a position corresponding to the most energy efficiency, based on for example current speed, navigation instructions, upcoming corners, or
10 the like. The driver may for example feel a small resistance, applied by the actuator, to be aware of the most energy efficient throttle control position. This allows the driver to be thought to drive more energy efficient. Additionally, said actuator may be used for driving lessons, to provide a driving student with feedback and to obtain a feeling for driving a vehicle.

15

According to a preferred embodiment the vehicle is a hybrid electric vehicle and/or a battery electric vehicle, further comprising at least one electric energy storage unit, preferably for storing electric energy for powering at least a part of the vehicle, in particular for powering at least a part of a drivetrain of said vehicle, and
20 preferably at least one electric motor, coupled to the electric energy storage unit, and directly or indirectly connected to at least one wheel of the vehicle, preferably wherein said at least one motor is configured for providing at least a part of the braking power, wherein at least a part of said braking power is a regenerative braking power. A cost-effective way to achieve fuel and/or energy efficacy and
25 economy is to reinforce positive driving behaviour and assist the driver in both acceleration and deceleration, for example through said actuator. Driving behaviour can be controlled if drivers can be alerted for behaviour that results in poor energy economy, both in acceleration and deceleration. To date, all driver aiding assistance are related to acceleration, where in this invention driver feedback from
30 the vehicle throttle control relating to the braking demand is also included as this will significantly improve energy efficiency. To date, merely visual information is given regarding the braking energy or braking power, but not regarding a braking strategy assistance, which is enabled through the present invention. Energy consumption is preferably tracked and monitored instantaneously rather than
35 tracking average energy economy, for example in kilo watt hours, for the entire trip

duration. This requires prediction of instantaneous energy consumption and detection of anomalous energy economy. In electrical vehicles this may include accurate estimation of the brake energy and driving energy, which will be aided by taking into account not only the position, but also the first and/or second and/or any consecutive integral, and optionally also any derivative, of the vehicle throttle control with due account for environmental variables, vehicle parameters and vehicle states.

In a preferred embodiment the braking power demand signal is determined based on a second and/or third and/or consecutive integral, and optionally also further derivative, of the at least one measured variable of the vehicle throttle control. By using the second and/or third and/or consecutive integral, and optionally also further derivative, of the at least one measured variable of the vehicle throttle control more information may be retained in the signal. Preferably, at least one measured variable of the vehicle throttle control is chosen from the group consisting of: position, velocity, acceleration, jerk, jounce, absement, absity, abseleration, abserk, absounce. Using these further integrals and optionally also derivatives, of a measured variable allows to obtain more detailed information regarding the wishes of a driver. That is, based on the mass of the vehicle throttle control times the acceleration, the force may be retrieved. This provides useful information regarding the demand that was made by the driver. Preferably, a control unit and/or processing device of the vehicle is configured for computing a secondary variable based on the at least one measured variable, preferably wherein said secondary variable may be: a force and/or an energy and/or an action and/or a power and/or a time and/or a length and/or a momentum and/or a yank and/or a tug and/or a snatch and/or a shake, preferably said secondary variable corresponding, directly or indirectly, to an action performed by a user to said vehicle throttle control. The force may be determined based on the mass of the throttle control times the acceleration, or by dividing the action by the absement. An energy may be determined based on the force times the displacement or based on the mass times the square of velocity. The action may for example be calculated based on mass times areolar velocity, or power times the square of time. A power could be determined based on the force divided by the presegment, or by the action divided by the square of time, or force times velocity. The skilled person would realize different ways to obtain such secondary variables based on the measured

variable. These variables may additionally be used in order to validate the demand provided by the driver.

Preferably, the vehicle throttle control is chosen from the group consisting of: a joystick, a pedal, a 3D-pedal, a sound, a handle, a rotational button, a remote control, a driver head movement. Here, the pedal is currently the most conventional use of throttle control. However, the present invention allows for more advanced and futuristic throttle controls while maintaining a predictable braking demand. A sound may for example be measured in decibel (dB), of which an increasing sound volume may for example correspond to a throttle demand or a braking demand. It is conceivable that for some of the throttle controls, additional and/or multiple variables may be measured, which may allow for additional accuracy in determining the braking power demand signal.

According to a preferred embodiment, the vehicle further comprises, at least one second vehicle throttle control, preferably according to any of the embodiments. It is conceivable each vehicle throttle control is configured for controlling a throttle power and at least a part of a braking power of the vehicle. This may be beneficial to obtain more flexibility in terms of vehicle control. In particular, wherein the vehicle comprises at least two motors, wherein each of the vehicle throttle controls is connected to a respective motor. Hence, the driver may according to this embodiment provide a braking and/or power demand towards either motors of the vehicle. One motor may be connected, directly or indirectly, to the left side wheels of the vehicle, whereas the other motor may be connected, directly or indirectly, to the right side wheels of the vehicle. By providing a power demand to the one of the throttle controls, and a braking power to the other throttle control (e.g., by releasing the throttle control) the vehicle may initiate a very sharp turn, in particular substantially around its own axis. Hence, the vehicle throttle control according to the present invention allowing for controlling a wheeled vehicle according to a track vehicle, without the need for applying tracks.

Preferably, the braking system is a brake-by-wire braking system and/or a regenerative braking system. A brake-by-wire system allows for the most effective control of the brake system. Moreover, it allows for easily adding or removing sensors, or adding or removing control units to the braking system.

Optionally, the braking power demand signal is used for a traction control and/or torque and/or speed and/or acceleration vectoring system. That is, based on a generated braking power demand signal, a control unit of the vehicle may define
5 how to divide the braking power over either friction brakes and/or by means of one of the motors to regenerate energy, if applied. Dividing the braking power over the friction brakes or via, in particular electric, motors may occur based on the braking power alone. However, preferably dividing occurs based on the braking power demand signal in combination with at least one drivetrain output parameter, such
10 as a steering angle. For example, in a left handed corner, it is preferred to provide more braking load towards the left side wheels of the vehicle to initiate a yaw. Similarly, during braking may be beneficial to provide a dynamic load, such as to reduce the pitch of the vehicle during braking. Preferably, a vehicle according to the present invention further comprises a vehicle braking control, in particular a vehicle
15 braking pedal, for controlling a braking demand. Although it is preferred to allow the driver to only use a single pedal, regulations currently prescribe the presence of a braking pedal. It is conceivable similar variable measurement and usage could be applied to the braking pedal as is thought in the present invention.

20 Optionally, the one-pedal power demand signal may be used for both an accelerating and decelerating traction control and/or power and/or torque and/or speed and/or acceleration vectoring system or the like. As such, when the vehicle travels in a straight line, the wheels on both sides of the vehicle rotate at very similar speeds. This rotational wheel speed alters during a vehicle cornering
25 manoeuvre and/or when the wheels have different radii, for example due to load mismatch between the left and right side of the vehicle. In such a case, the outer vehicle wheels travel along a larger turning radius, hence must cover a larger distance compared to the inner vehicle wheels in the same amount of time. This is typically encountered for through application of a vehicle axis differential. A vehicle
30 differential allows the vehicle wheels to rotate independently at different speeds. For most current vehicle today, these differentials are the basis for the vehicle torque-vectoring system, as this differential allows to vary the wheel torque to each wheel based on the wheel grip and wheel traction the system detects. As such, the vehicle's handling characteristics may be adjusted to handle slippery surfaces
35 and/or enhance cornering performance and/or straight line drag racing and/or split

friction surfaces or the like. According to this embodiment at least one electric motor combined with the brake system may act as a differential-based torque-vectoring systems, in particular if combined with an open differential instead of using a combination of clutches on each vehicle side. This advanced differential-based torque vectoring using the brake system, motor and an open differential as all aforesaid implementations of the one-pedal system can be applied in conjunction with all-wheel drive.

Optionally the single pedal signal(s) allow(s) the vehicle motor and brake to replicate a more advanced differential-based vehicle system behaviour. In this respect, brake-based and/or tyre-based advanced torque vectoring enables a cost-effective power delivery to the individual vehicle wheels. Here a control unit may momentarily apply a braking power either by motor and/or friction brake to one of the wheels during a turn or minimize the braking in case excessive tyre wear is being detected as feedback to the driver the level of tyre wear is not envisaged at this moment. In performance applications, currently the key disadvantage of the nowadays used brake-based and/or tyre-based systems relates to vehicle speed and vehicle durability. As using solely the friction brakes and maximizing tyre-wear to advance cornering usually results in longer lap times that also depend on the tyre wear compared to a differential-based system as currently implemented. Further, managing brake overheating and/or overall brake wear and/or brake tear and/or brake pad particles and/or tyre wear and/or maximize tyre-road force is a challenge. Using a motor that allows for much more efficient transformation of the vehicle kinetic energy into electrical energy, hence with significantly less heat production, allows for a different brake-based and/or tyre-based advanced torque vectoring as now an improved vehicle stability can be achieved combined with the single pedal sensing. This electric brake-based and/or tyre-based torque vectoring can also be implemented when two or more electric motors are connected to a single vehicle wheel. This allows for one of the purest forms of torque vectoring during both acceleration as deceleration, as each wheel can be individual controlled with up to 100 percent of the available vehicle torque, as such full lateral torque vectoring, hence power, by combining the motor and the brake system, this could be in combination with tyre wear status. Hence, it is conceivable that the application of the accelerating and/or decelerating traction control and/or torque

and/or speed and/or acceleration vectoring system may be applied separately without in doing so requiring all features of the present invention.

It is conceivable that the control unit is configured for determining a magnitude of the braking power based on a minimized tyre wear and/or minimized brake wear, and/or minimized tyre particle emission and/or minimized brake particle emission. This may be achieved by means of particular vehicle powertrain output variables, such as vehicles speed, and/or cornering speed and/or tyre characteristics, and/or vehicle-tyre-models or the like. Based on the parameters the braking strategy may be adjusted by the control unit. For example, in order to minimize brake wear, the braking power may be maximally directed towards the regenerative motor, in order to prevent excessive brake wear. To minimize tyre wear, the control unit may determine, based on for example a projected brake trajectory, a minimum braking power to arrive at a desired deceleration over the full trajectory. The regenerative braking power level is closely related to the tyre-ground contact force, hence also tyre wear. For example, if the centre of gravity of the car is positioned exactly in the centre of the four wheels and the cornering stiffness of the four tires is exactly identical, the steering characteristic of the car is neutral. As a consequence, up to a certain deceleration negative torque request the car will regenerate, however at a certain deceleration negative torque request the car will start to slide in the forward vehicle direction, hence speed of the wheel becomes zero. At this point, the maximum lateral deceleration is reached and the regenerative power will diminish to zero, as power is torque multiplied by angular velocity. Further decelerating the car will lead to more lateral slip and usually an anti-lock braking strategy will be implemented, or an alternative strategy when the vehicle is cornering. Optionally, this information is fed back to the driver via the vehicle throttle control, to inform the driver about the low level of longitudinal force produced by the tires, hence the produced lateral force and the vehicle's lateral deceleration will approach their maximum. Albeit that, for example, an advanced active electromagnetic suspension system has the means to momentarily alter the tyre-road force by suddenly lifting the body, hence increasing the available regenerative braking energy. An active suspension system allows to optimize ride comfort and road holding and is capable of decreasing the rolling of the vehicle's body during cornering and therefore maintaining an optimal orientation of the tires with respect to the road and regenerative braking power level. As such, the electric motor could be equipped

with a, for example, maximum power point tracking strategy to achieve the highest level of regenerative power that will feed into the energy storage. Therefore the present invention also provides input or feedback, in particular via the feedback actuator, and/or other feedback means, in situations of certain levels of longitudinal
5 force produced by the tire or situations an emergency situation which is the case when the level is so low that the vehicle loses its grip. Loosing grip also leads to excessive tyre wear. This informing via the vehicle throttle control can be, for example, by quickly moving the pedal up and down and/or an audible sound and/or a visual feedback and/or a vibration and/or a combination thereof.

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According to a different aspect the present invention provides a single pedal throttle control braking system for use in a vehicle, preferably a vehicle according to the present invention, comprising a vehicle throttle control, for controlling the vehicle
15 throttle signal and at least a part of a vehicle braking demand signal, at least one sensor, for measuring at least one vehicle throttle control variable, preferably at least one control unit and/or processor, communicatively connected to the at least one sensor, for determining a braking power demand signal based on an integral, and optionally also a derivative, of the at least one measured vehicle throttle control
20 variable received from said at least one sensor.

Notice should be made here that the braking system according to the present invention relates to a single pedal braking system, similar to the vehicle according to the present invention. This may also be referred to a single throttle control
25 braking system for use in a vehicle. That is, the vehicle throttle control according to the single pedal throttle control braking system allows for controlling both a throttle and a braking power. The present invention in particular aims at improving the braking capabilities of the throttle control with account for friction brake wear and tyre wear. The single pedal throttle control braking system may be counter fitted in
30 existing vehicles with separate braking pedals to obtain the benefits as disclosed in the aforementioned portion of the application relating to the vehicle. Hence, the single pedal throttle control braking system is not limited to the throttle control being a dedicated pedal, nor is this aspect of the invention limited to the mere use of a single pedal. This shall be understood as the single pedal system being arrange to
35 allow for braking, in particular more intuitive braking, through the throttle control.

This does not exclude the application of a separate brake pedal, nor does it exclude the application of a second vehicle throttle control according to this aspect.

Here, the control unit and/or processor and/or processing unit being
5 communicatively connected to the at least one sensor may be understood as the control unit and/or processor being able to receive the data obtained by the at least one sensor. Should the vehicle throttle control already comprise such a sensor that may also be utilized. By using the integral, and optionally also the derivative, of the
10 at least one measured variable it is possible to obtain a more predictive braking power and/or tyre wear and/or brake wear and/or particle emission from tyre and/or particle emission from brake. It is conceivable that the braking power demand signal and/or tyre wear and/or brake wear and/or particle emission from tyre and/or particle emission from brake determined by the system according to the present invention is solely used in part in addition to an existing braking system.

15 Preferably the system, in particular the control unit and/or processor, is configured for communicating the determined braking power demand signal to a braking system. This may allow the braking power demand signal to provide for at least a portion of the braking power. Preferably, the system further comprises at least one
20 energy storage unit, such as a battery, for storing of recuperated regenerative braking energy. The battery of the system may be configured specifically to receive energy from an electric motor acting as a generator based on the at least one braking power demand signal.

25 According to a further aspect the present invention provides a method for single pedal driving in a vehicle, in particular a vehicle according to the present invention, comprising the steps of: A) providing a vehicle throttle control, preferably according to the present invention; B) measuring at least one variable of the vehicle throttle control, preferably continuously, C) determining a braking demand signal based on
30 the integral, and optionally also the derivative, of the measured variable of step B); and D) sending of a braking instruction to a braking system based on the braking demand signal of step C). The same benefits as elucidated based on the vehicle and/or braking system according to the present invention apply similarly to the method according to the present invention.

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Preferably, the derivative is based on a position of the vehicle throttle control, in particular being a position of a vehicle throttle pedal. Such a position may be an angular position, such that the derivative thereof yields an angular speed. Yet, in case of a linear pedal it is conceivable that a regular x-y-z coordinate position is used.

Preferably, the method further comprises step E) receiving at least one drivetrain output variable, preferably from a vehicle control unit. By receiving at least one drivetrain output variable overall integration of the single pedal driving may be improved. In particular wherein during step C) the braking power demand signal is based on the integral, and optionally also the derivative, of the measured variable of step B) and the at least one drivetrain output variable received in step E). This may allow for a braking power demand signal that provide an intuitive braking force.

Preferably, the method further comprises the step of determining an available regenerative braking power, and comparing the braking power demand signal with the available regenerative braking power, and allocating the braking power demand signal to a regenerative braking system if the amount of available regenerative braking power is larger than the braking power request of the braking power demand signal; or allocating a first part, preferably a maximum part, of the braking power request of the braking power demand signal to said regenerative braking system and allocating a second part of said braking power request of the braking power demand signal to at least one alternative braking element if the available regenerative braking power is smaller than the braking power request of the braking power demand signal.

The present invention will hereinafter be elucidated in more detailed based on the following non-limitative figures, wherein:

- Figure 1 shows a one-pedal driving system according to the prior art;
- Figures 2a and 2b show a basic overview of a regenerative braking methodology according to the prior art;
- Figure 3 shows a more detailed regenerative braking methodology according to the prior art;
- Figure 4 shows a vehicle according to the present invention;

- Figure 5 shows a first embodiment of a single pedal throttle braking system according to the invention; and
- Figure 6 shows a different embodiment of a single pedal throttle braking system according to the invention.

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Figure 1 shows an example of a pedal assembly 10 for driving a vehicle according to the prior art. The example shown in this figure is specifically related to a hybrid or electric vehicle. In this example, the system 10 comprises a throttle control 2 as well as a brake control 1, both in the form of a pedal. The driver may control the throttle control 2 and brake control 1 using his/her feet. The brake control 1 comprises a cylinder 3 which is known in the art. Via said cylinder 3, the brake control 1 is able to provide a braking power demand signal to a control unit 8, the braking power demand signal may comprise information regarding a brake pressure 4. The throttle control 2 provides, as an input to the control unit 8, a throttle control position 7. If the throttle control 2 is fully pressed, this corresponds to a position of 100%, whereas a fully released throttle control 2 would correspond to a throttle position 7 of 0%. The throttle demand of the vehicle may be based on the throttle position 7. In order to allow the control unit 8 to control the vehicle, it may receive vehicle parameters, such as a vehicle speed 5. Using the received information from the brake control 1 and the throttle control 2, the control unit 8 may instruct an inverter 9. Such an instruction from the control unit to the inverter may comprise a torque setpoint. The inverter 9 typically being installed between a battery and a motor 11 of a vehicle. The inverter 9 will in regular operation, provide a current to the motor 11 based on the torque setpoint received from the control unit 8. Typically, hybrid or electric vehicles are configured for regenerating energy via the electric motor 11. By using the motor 11 as a generator, it is possible to convert the kinetic energy into electric energy which may be stored in a battery of the vehicle. By using the regenerative braking capabilities of electric motors, it is possible to increase the electric range of hybrid or electric vehicles and/or minimize tyre wear and/or minimize brake wear and/or minimize particle emission from tyre and/or minimize particle emission from brake. Currently, however, the use of regenerative braking is not optimal, in particular since it is not intuitive and therefore not easily usable by drivers, as will be elucidated based on the figures 2a, 2b, and figure 3.

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Figure 2a shows a first graph which shows the torque setpoint (τ) input signal for the inverter on the vertical axis, and the throttle position (p) on the horizontal axis. The blue line in the graph shows the relation between said parameters. The blue line starts on negative torque setpoint values, and crosses the zero-torque setpoint on point 13. This is introduced to allow for negative torques in the area below the vertical axis, to allow for regenerative braking. The free-play 12 in the throttle pedal position (p) corresponds to the point between 0% and the part where the blue line crosses the zero-torque line. If the vehicle is at a standstill, this holds that the first movement of the throttle does not yield an acceleration since the torque required to accelerate the vehicle from standstill should be larger than zero. However, if the vehicle is driving at a specific speed, and the throttle pedal is released, to beyond position indicated by point 13, the torque setpoint provided is negative, hence resulting in deceleration of the vehicle to allow for regenerative braking. Figure 2b shows a basic vehicle speed dependency of the regenerative braking force. That is, it may be undesirable to allow for maximum regenerative braking torque at high speed. In particular, driving on a highway at higher speeds it may not be beneficial if full release of the throttle pedal (hence to 0%) yields a maximum regenerative braking since this is not typically desired and may bring dangerous situations on the road. Therefore, the regenerative braking may be partially based on a vehicle speed. The graph in figure 2b shows the maximum regenerative braking torque setpoint $\tau(v)$ on the vertical axis, versus the vehicle speed (v) on the horizontal axis. Between speeds indicated at points 14 and 15 a maximum regenerative braking is available upon full release (0%) of the vehicle throttle pedal. From vehicle standstill up to a specific low speed, at point 14, the amount of regenerative braking torque steadily raises from its lowest value 18 to its highest value, at point 17. As discussed, it may not be desired to allow for maximum regenerative braking at high speeds (e.g., point 16), which explains why the maximum available regenerative braking torque setpoint decreases from speeds at point 15 towards speeds at point 16. Summarizing, the inverter torque input τ may vary between negative values and positive values, negative values corresponding to a regenerative braking torque setpoint, based on a certain pedal position. Within the regenerative braking torque setpoint regime, the maximum available torque setpoint may be dependent on a current vehicle speed (v).

The example according to the prior art indicated in figures 2a and 2b is however rather limitative. In recent years developments have yielded more complex integration maps for regenerative braking methodologies. Figure 3 shows an example of a regenerative braking methodology that may be used for hybrid or electric vehicles. Here, a more complex integration of the vehicle throttle control position p (horizontal axis) is shown versus a vehicle speed v (vertical axis), wherein the different lines correspond to different regenerative braking torque setpoints. The constant velocity line, indicated by reference number 20 separates an acceleration zone, on the right side of the constant velocity line 20, and a regeneration zone, on the left side of the constant velocity line 20. A specific area 19 in the regenerative braking zone corresponds to the situation where the vehicle is coasting. The essence of coasting is that the amount of energy consumption and the amount of energy generation match with each other, hence the vehicle moving without use of energy. However, the torque setpoint being dependent on vehicle velocity and throttle control position imparts some major downsides. For instance, there remains an abrupt separation between the accelerating and the regenerative braking domains of the vehicle, which will be noticeable to a driver of the vehicle. That is, whilst driving at a constant speed release of the throttle control initiates a predetermined specific regenerative braking action, based on how far the throttle control is released. In some instances, a driver is able to change the map, such as the one indicated in this figure, to change between a more aggressive regenerative braking methodology, or a more subtle regenerative braking methodology. However, even though this provides a user with more flexibility, it does not yield an intuitive system. Therefore, current single pedal driving systems are rather limited.

Figure 4 shows a non-limitative embodiment of a vehicle 100 according to the present invention. The vehicle 100 shown in the figure is merely schematically, and it is to be understood that more systems may be present. The figure merely serves the purpose to enlighten the inventive concept of the present invention based on this non-limitative embodiment. The vehicle comprises a total of four wheels 104, which may represent a car 100. The inventive concept according to the present invention may however equally well be applied to a motorcycle, or the like. Each wheel 104 is provided with a motor 105 or two wheels are provided with a single motor via a differential or only one axis is provided by a motor/differential combination, which may be housed in a chassis of the vehicle 100 and connected

to the wheels 104 by means of a driveshaft, or the motors 105 may be housed inside the wheels, acting as part of an in-wheel assembly. The number of motors 105 may be changed, according to design requirements of the vehicle 100. The motors 105 serve the purpose to provide a drive power to the vehicle 100. The vehicle as shown in this non-limitative figure being a battery electric vehicle 100, the motor may additionally serve as a regenerative brake or torque boost. The vehicle 100 is furthermore equipped with a brake system 106, which may be partially formed by braking disks and callipers 106 applied on the front two wheels 104. However, it is very much conceivable, in particular owed to the fact the vehicle is an electric vehicle 100, that one or more motors 105 may form at least a part of the braking system, in the sense that the regenerative braking power applicable through the motors 105 achieves a similar result (deceleration of the vehicle 100) compared to the brake disks with callipers 106. To drive the vehicle, a one-pedal driving system 102 may be provided. This particular embodiment however comprises two vehicle throttle controls 103, preferably each for providing a throttle power. It is however conceivable to provide just a single vehicle throttle control 103 to allow for pure one-pedal driving according to the invention. The vehicle throttle control 103 allows not only for providing a throttle power 109, but also at least a part of a braking power of the vehicle 100. This particular embodiment provides for further benefits since it is provided with two throttle controls 103, each allowing for controlling a throttle power 109 and at least a part of the braking power. This may be efficiently used, for example by arranging a first throttle control 103 to control the throttle power 109 of the left side motors 105, and the second throttle control 109 to control the throttle power 109 of the right side motors 105. Alternative usage, such as a front-rear distinction is also conceivable. The braking system, which may be formed by the braking disks and callipers 106, and/or the electric motors 105 as discussed before may be arranged to provide the braking power to the vehicle. The braking power is at least partially based on a braking power demand signal or minimize tyre wear or minimize brake wear or minimize particle emission from tyre or minimize particle emission from brake or any combination thereof. Said braking power demand signal is based on an integral, and optionally also a derivative, of at least one measured variable of the throttle control 103. To this end, each throttle control 103 in this embodiment is provided with a sensor 112, which is configured for measuring said integral, and optionally also said derivative, of the variable. To obtain this integral, and optionally also this derivative, value the sensor may directly

measure said integral, and optionally also said derivative, value directly, or a control unit 108 is arranged to receive raw data, and compute the integral, and optionally also the derivative, value thereof. However, it is preferred that the sensor 112 is configured to directly measure the derivative, and optionally also the derivative, value. Thus, the sensor 112 is communicatively connected 107 to the control unit 108. Said control unit may be a vehicle control unit 108, or a throttle control system control unit 108. Hence, the control unit 108 in this aspect should be understood broadly. It may also be conceivable that the control unit 108 is part of an inverter (not shown) which instructs the electric motors 105. In this schematic figure, it is for illustrative purposes indicated the control unit 108 is connected communicatively 110 to the motors 105. Also, this figure indicates two separate control units 108, one in the front and one in the rear of the vehicle 100. However, the skilled person may readily understand that this may also be a single control unit 108, and located anywhere in the vehicle 100. It may also be the case that there are four separate control units 108, one for each wheel 104. The communicative connection 110 between the control unit(s) 108 and the motors allows for sending instructions to the motors 105. Such instruction may for example be a full throttle instruction. Full throttle may correspond to a maximum torque output towards the motor. Conceivably, if a wheel spin 104 is detected upon said maximum torque signal, a vehicle control unit, such as 108, may temporarily lower the torque setpoint to reduce the wheel slip. Since the vehicle 100 shown in this figure is an electric vehicle, a vehicle storage unit 101 is provided in the form of two batteries. It is conceivable the two batteries are in a master and slave configuration, wherein the master battery 101 is in communication 111 with the control unit 108. It is conceivable the control unit 108 receives drivetrain output parameters from, e.g., the batteries 101.

Figure 5 shows a first non-limitative embodiment of the single pedal throttle braking system 200 according to the invention. As discussed previously, the single pedal throttle braking system 200 is not limited to merely single pedal systems, neither is this aspect limited to the mere use of pedals. The single pedal throttle control braking system 200 in this particular embodiment comprises a throttle pedal 201 which may be accessed by a driver to control the vehicle speed and to control at least a part of the vehicle braking demand. The control unit 207 of the single pedal throttle control braking system 200 may receive, among other, a vehicle speed 204

as an input signal. Yet it is also conceivable that instead, or in addition to said vehicle speed 204 information relating to a state of charge of a vehicle energy storage unit, such as a battery, or the like is received. In addition to said vehicle speed input 204 an additional signal 202 is provided to said control unit 207. The
5 additional signal 202 may relate to data from a sensor 203, which sensor is configured for measuring at least one variable of the vehicle throttle control, such as its position or velocity. Based on an integral, and optionally also a derivative, value of such measured variable, at least a part of the braking power demand signal is constructed. Constructing said braking power demand signal may be
10 realized through the control unit 207, or via an inverter 206 which is coupled to a motor 205 and battery 209. However, it is also conceivable that another, further processor or control unit determines said derivative, and optionally also said derivative, of the measured variable of the vehicle throttle control 201. Yet it is also possible said sensor 203 is chosen such as to allow for direct measurement of an
15 integral, and optionally also an derivative, value. The control unit 207 may provide instructions to the inverter 206. For example, the control unit may instruct the inverter 206 to provide a positive torque to the motor 205, by supplying energy from the battery 209 towards the motor. However, if the throttle pedal 201 is released, a braking power demand signal is constructed. The braking power magnitude e.g.,
20 depending on the speed at which the throttle pedal 201 is released. The control unit 207 may instruct the inverter 206 to apply a braking power by allowing the motor 205 to function as generator to convert kinetic energy into electric energy, which may subsequently be stored in the battery 209, hence increasing a range of a vehicle in which the single pedal throttle control braking system 200 is installed. In
25 this embodiment, the vehicle throttle pedal 201 is furthermore provided with a feedback actuator 210. Said feedback actuator allowing for providing a user feedback and/or user reference position through the vehicle throttle control 201. Said feedback actuator 210 may be instructed by the control unit 207, based on vehicle parameters. For example, it is conceivable that the feedback actuator is
30 arranged to provide a braking feedback in the vehicle throttle control 201. This may allow the driver to have a braking experience which more accurately corresponds to a braking experience when using a dedicated brake pedal. This may for example be achieved by setting the feedback actuator to push dependent on the braking power demand signal, which allows the driver to more intuitively experience, or at

least have a better feeling, as to what braking force is about to be exerted by the release of the pedal 201.

Figure 6 shows a different non-limitative embodiment of the single pedal throttle braking system 200 according to the invention. Here, it can be seen that the single pedal throttle braking system 200 is not limited to the use of merely a single pedal. In fact, here a first vehicle throttle control 201a and a second vehicle throttle control 201b, each in the form of a pedal 201a, 201b, are provided. The driver may use both of the pedals 201a, 201b. Here it may be conceivable that the first vehicle throttle control 201a is arranged to control, in particular the throttle power and at least a part of the braking power of a first motor 205a, or first set of motors, e.g., provided on a first side of a vehicle. The other vehicle throttle control 201b may be arranged to control, in particular the throttle power and at least a part of the braking power of a second motor 205b, or second set of motors, e.g., provided on a second opposing side of the vehicle. It is possible that each of the motors 205a, 205b each are provided with an inverter 206a, 206b, such as indicated in this figure. However it is also conceivable both motors are connected to a single inverter. Preferably each inverter is connected to a battery 209, which may be the same battery 209 or a group of batteries 209. By providing two vehicle throttle controls 201a, 201b it is possible to drive the vehicle in a more flexible manner. For example, each throttle control 201a, 201b, may be arranged to provide a throttle demand or braking demand to a specific side of a car. In this respect, each of the pedals 201a, 201b may be provided with a sensor 203 (not specifically indicated, but may be the same as shown in figure 5), based upon which sensor dedicated first additional signals 202a and second additional signals 202b may be provided to the control unit 207. Such dedicated first and second additional signals 202a, 202b may correspond to sensor-data from the sensors applied to the first and second pedal 201a, 201b. This may allow for driving the car like a vehicle with tracks, whilst it may comprise wheels. This may enable very sharp turns. Moreover, the use of the vehicle throttle control according to the invention provides for more intuitive braking with said throttle control pedal 201a, 201b. The first vehicle throttle control 201a may move between its two outermost positions, indicated with the continuous lines 201a, 212. Between said two outermost positions 201a, 212, a zero-position 211 may be provided. This may either be a stationary zero position 211 or a dynamic zero-position 211. Such a zero-position 211 may be utilized to separate the throttle and

the braking portion of the pedal 201a. Although it is merely indicated one of the vehicle throttle controls comprises such a zero-position 211, it is well conceivable that each of the pedals 201a, 201b comprises a zero-position 211. Additionally, if a vehicle throttle control 201a, 201b is provided with a feedback actuator 210, such as indicated in figure 5, said feedback actuator 210 may be arranged to provide a sensible feedback if the throttle pedal 201a, 201b passes said zero-point 211.

Where it is noted that components are communicatively connected to each other, it must be understood that this may be both wired as well as wireless. Components may for example allow for communication through Bluetooth, CAN-lines and/or other communication channels.

The above-described inventive concepts are illustrated by several illustrative embodiments. It is conceivable that individual inventive concepts, including inventive details, may be applied without, in so doing, also applying other details of the described embodiments. It is not necessary to elaborate on examples of all conceivable combinations of the above-described inventive concepts, as a person skilled in the art will understand numerous inventive concepts can be (re)combined in order to arrive at a specific application and/or alternative embodiment.

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The ordinal numbers used in this document, like “first”, “second”, and “third” are used only for identification purposes. Hence, the use of expressions like a “second” component, does therefore not necessarily require the co-presence of a “first” component. By “complementary” components is meant that these components are configured to co-act with each other. However, to this end, these components do not necessarily have to have complementary forms. The verb “comprise” and conjugations thereof used in this patent publication are understood to mean not only “comprise”, but are also understood to mean the phrases “contain”, “substantially consist of”, “formed by” and conjugations thereof.

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Claims

1. A vehicle, in particular an electric vehicle comprising an electric powertrain and at least one, preferably electric, energy storage unit, comprising a one-
5 pedal driving system, comprising:
- at least one vehicle throttle control, for controlling a throttle power and at least a part of a braking power of the vehicle;
 - at least one braking system, configured for providing the braking power to the vehicle, wherein said braking power is at least partially based on a
10 braking power demand signal,
- wherein said braking power demand signal is, at least partially, determined based on at least an integral of at least one measured variable of the vehicle throttle control.
- 15 2. Vehicle according to claim 1, wherein said braking power demand signal is, at least partially, also determined based on a derivative of at least one measured variable of the vehicle throttle control.
- 20 3. Vehicle according to claim 1 or 2, wherein the vehicle, in particular the at least one vehicle throttle control, comprises at least one sensor for measuring said integral, and optionally also said derivative, of the at least one measured variable.
- 25 4. Vehicle according to claim 3, wherein said sensor is a gyro and/or a gps-sensor and/or a rotational sensor and/or position sensor.
5. Vehicle according to any of the preceding claims, wherein the vehicle further comprises at least one control unit, wherein the control unit is configured for:
- determining, based on the integral, and optionally also the derivative, of
30 the at least one measured variable, a braking power demand signal, and
 - instructing, based on the braking power demand signal, the braking system, preferably a regenerative braking system.
- 35 6. Vehicle according to claim 5, wherein the control unit is further configured for receiving at least one drivetrain output variable, preferably wherein the braking power demand signal is determined based on the integral, and

optionally also the derivative, of the at least one measured variable of the vehicle throttle control and the at least one drivetrain output variable.

- 5 7. Vehicle according to claim 6, wherein the drivetrain output variable is chosen from the group comprising: a state of charge of at least one energy storage unit, in particular an electric energy storage unit such as a battery, a vehicle speed, a vehicle current gear, a vehicle battery and/or motor temperature, a vehicle acceleration, a vehicle steering wheel orientation.
- 10 8. Vehicle according to one of the claims 5-7, wherein the control unit is further configured for validating the determined braking demand signal, in particular based on a secondary variable and a drivetrain output variable.
- 15 9. Vehicle according to any of the claims 5-8, wherein the control unit is configured for determining an available regenerative braking power, and comparing the braking power demand signal with the available regenerative braking power, and;
- 20 • Allocate the braking power demand signal to a regenerative braking system if the amount of available regenerative braking power is larger than the braking power request of the braking power demand signal;
- Allocate a part, preferably a maximum part, of the braking power request of the braking power demand signal to said regenerative braking system and allocate a remainder of said braking power request of the braking power demand signal to at least one alternative braking element if the
- 25 amount of available regenerative braking power is smaller than the braking power request of the braking power demand signal.
- 30 10. Vehicle according to any of the claims 5-9, wherein the control unit is further configured to adjust a magnitude of the braking power corresponding to the braking power demand signal, preferably based on artificial intelligence by storing the integral, and optionally also the derivative, values of the measured variable of the vehicle throttle control of historic occurrences.
- 35 11. Vehicle according to any of the claims 5-10, wherein the control unit is further configured for, preferably continuously, determining an

instantaneously available braking power, preferably based on the integral of the at least one measured variable of the vehicle throttle control.

- 5 12. Vehicle according to any of the claims 5-11, wherein the control unit is configured for determining a magnitude of the braking power based on a minimized tyre wear and/or minimized brake wear, and/or minimized tyre particle emission and/or minimized brake particle emission.
- 10 13. Vehicle according to any of the preceding claims, wherein the vehicle throttle control is at least moveable in a first direction, and at least one second direction, wherein the first and second direction are mutually different, and wherein the vehicle braking demand signal is determined based on the integral, and optionally also the derivative, of the at least one measured variable of the vehicle throttle control in one of the first or second
- 15 direction, preferably wherein the other direction controls the vehicle throttle demand.
- 20 14. Vehicle according to claim 13, wherein a zero-position separates the throttle demand and the braking demand of the vehicle throttle control, wherein a control unit is configured for dynamically varying the zero-position.
- 25 15. Vehicle according to any of the preceding claims, wherein the vehicle, in particular the vehicle throttle control, comprises at least one feedback actuator, directly or indirectly connected to the vehicle throttle control, for providing a user feedback and/or a user reference position through the at least on vehicle throttle control.
- 30 16. Vehicle according to claim 15, wherein the feedback actuator is configured to provide a feedback to the user when the vehicle throttle control passes a vehicle throttle control mid position.
- 35 17. Vehicle according to any of the preceding claims, wherein the vehicle is a hybrid electric vehicle and/or a battery electric vehicle, further comprising:
- at least one electric energy storage unit, for storing electric energy for powering at least a part of the vehicle, in particular for powering at least a part of a drivetrain of said vehicle, and

- at least one electric motor, coupled to the electric energy storage unit, and directly or indirectly connected to at least one wheel of the vehicle, wherein said at least one motor is configured for providing at least a part of the braking power, wherein at least a part of said braking power is a regenerative braking power.

18. Vehicle according to any of the preceding claims, wherein said braking power demand signal is determined based on second and/or third and/or consecutive integral, and optionally also derivative, of the at least one measured variable of the vehicle throttle control.

19. Vehicle according to any of the preceding claims, wherein at least one measured variable of the vehicle throttle control is chosen from the group consisting of: position, velocity, acceleration, jerk, jounce, absement, absity, abseleration, abserk, absounce.

20. Vehicle according to any of the preceding claims, wherein a control unit and/or processing device of the vehicle is configured for computing a secondary variable based on the at least one measured variable, wherein said secondary variable may be: a force and/or an energy and/or an action and/or a power and/or a time and/or a length and/or a momentum and/or a yank and/or a tug and/or a snatch and/or a shake, preferably said secondary variable corresponding, directly or indirectly, to an action performed by a user to said vehicle throttle control.

21. Vehicle according to any of the preceding claims, wherein the vehicle throttle control is chosen from the group consisting of: a joystick, a pedal, a 3D-pedal, a sound, a handle, a rotational button, a remote control, a driver head movement.

22. Vehicle according to any of the preceding claims, the vehicle further comprising, at least one second vehicle throttle control.

23. Vehicle according to claim 22, wherein each vehicle throttle control is configured for controlling a throttle power and at least a part of a braking power of the vehicle.

24. Vehicle according to claim 22 or 23, wherein the vehicle comprises at least two motors, wherein each of the vehicle throttle controls is connected to a respective motor.
- 5 25. Vehicle according to any of the preceding claims, wherein the braking system is a brake-by-wire braking system and/or a regenerative braking system.
- 10 26. Vehicle according to any of the preceding claims, wherein the braking power demand signal is used for a traction control and/or torque vectoring system.
27. Vehicle according to any of the preceding claims, the vehicle further comprising a vehicle braking control, in particular a vehicle braking pedal, for controlling a braking demand.
- 15 28. A single pedal throttle control braking system for use in a vehicle according to any of the preceding claims, comprising:
- A vehicle throttle control, for controlling the vehicle throttle signal and at least a part of a vehicle braking demand signal;
 - 20 • At least one sensor, for measuring at least one vehicle throttle control variable
 - At least one control unit and/or processor, communicatively connected to the at least one sensor, for at least partially determining a braking power demand signal based on an integral of the at least one measured vehicle
 - 25 throttle control variable received from said at least one sensor.
29. Single pedal throttle braking system according to claim 28, wherein the at least one control unit and/or processor is communicatively connected to the at least one sensor, for at least partially determining a braking power
- 30 demand signal also based on a derivative of the at least one measured vehicle throttle control variable received from said at least one sensor.
- 35 30. Single pedal throttle braking system according to claim 28 or 29, wherein the system, in particular the control unit and/or processor, is configured for communicating the determined braking power demand signal to a braking system.

31. Single pedal throttle braking system according to any of the claims 28-30, the system further comprising at least one battery, for storing of recuperated regenerative braking energy.
- 5 32. Method for single pedal driving in a vehicle according to any of the claims 1-27 comprising the steps of:
- A) providing a vehicle throttle control, preferably according to one of the claims 28-31;
- 10 B) measuring at least one variable of the vehicle throttle control, preferably continuously,
- C) determining a braking demand signal based on the integral, and optionally also the derivative, of the measured variable of step B); and
- D) sending of a braking instruction to a braking system based on the braking demand signal of step C).
- 15 33. Method according to claim 32, wherein the derivative is based on a position of the vehicle throttle control, in particular being a position of a vehicle throttle pedal.
- 20 34. Method according to any of the claims 32 or 33, wherein the method further comprises step E) receiving at least one drivetrain output variable, preferably from a vehicle control unit.
- 25 35. Method according to claim 34, wherein during step C) the braking power demand signal is based on the integral, and optionally also the derivative, of the measured variable of step B) and the at least one drivetrain output variable received in step E).
- 30 36. Method according to any of the claims 32-34, comprising the step of determining an available regenerative braking power, and comparing the braking power demand signal with the available regenerative braking power, and;
- allocating the braking power demand signal to a regenerative braking system if the amount of available regenerative braking power is larger
- 35 than the braking power request of the braking power demand signal; or

- allocating a first part, preferably a maximum part, of the braking power request of the braking power demand signal to said regenerative braking system and allocating a second part of said braking power request of the braking power demand signal to at least one alternative braking element if the available regenerative braking power is smaller than the braking power request of the braking power demand signal.

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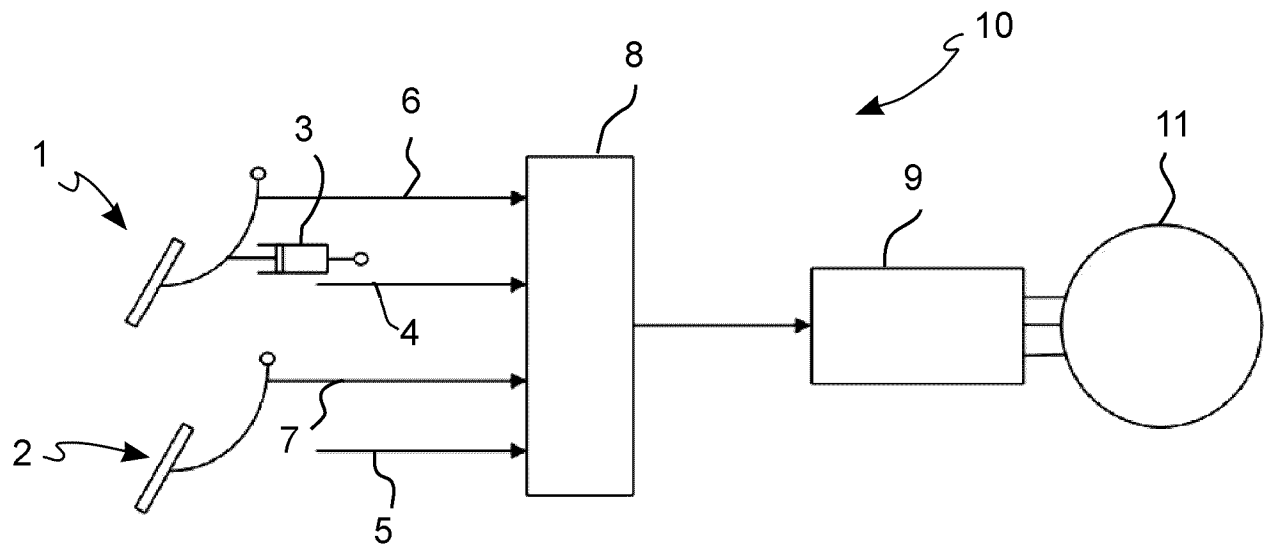


FIG. 1

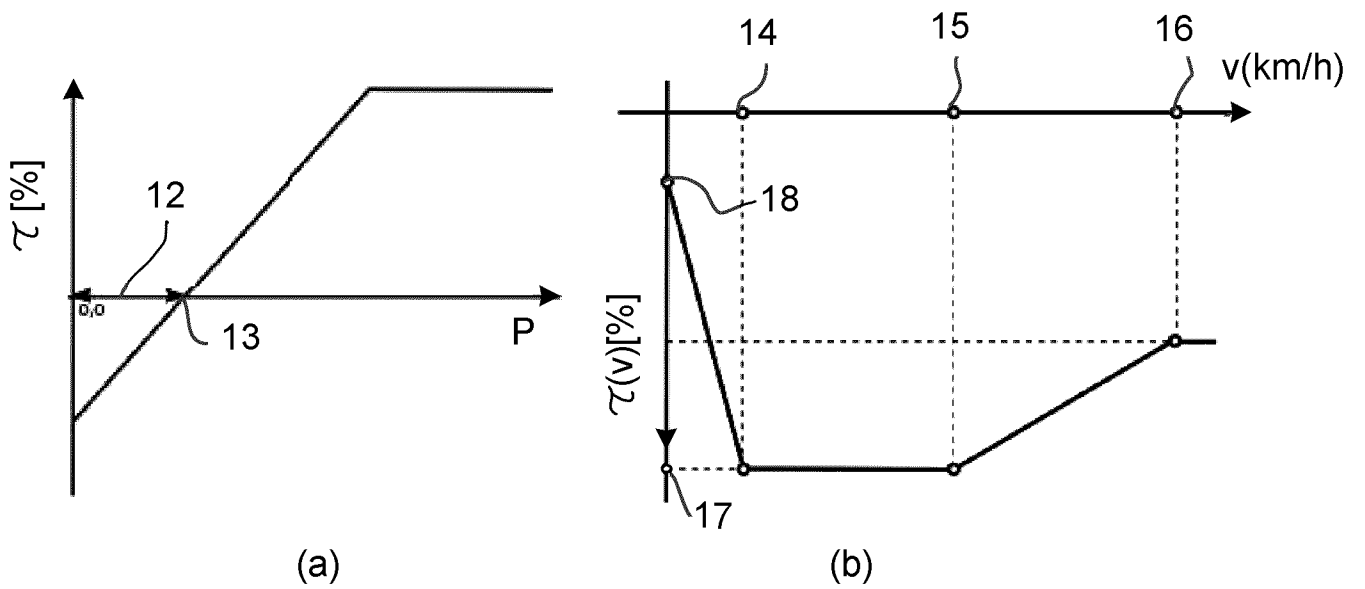


FIG. 2

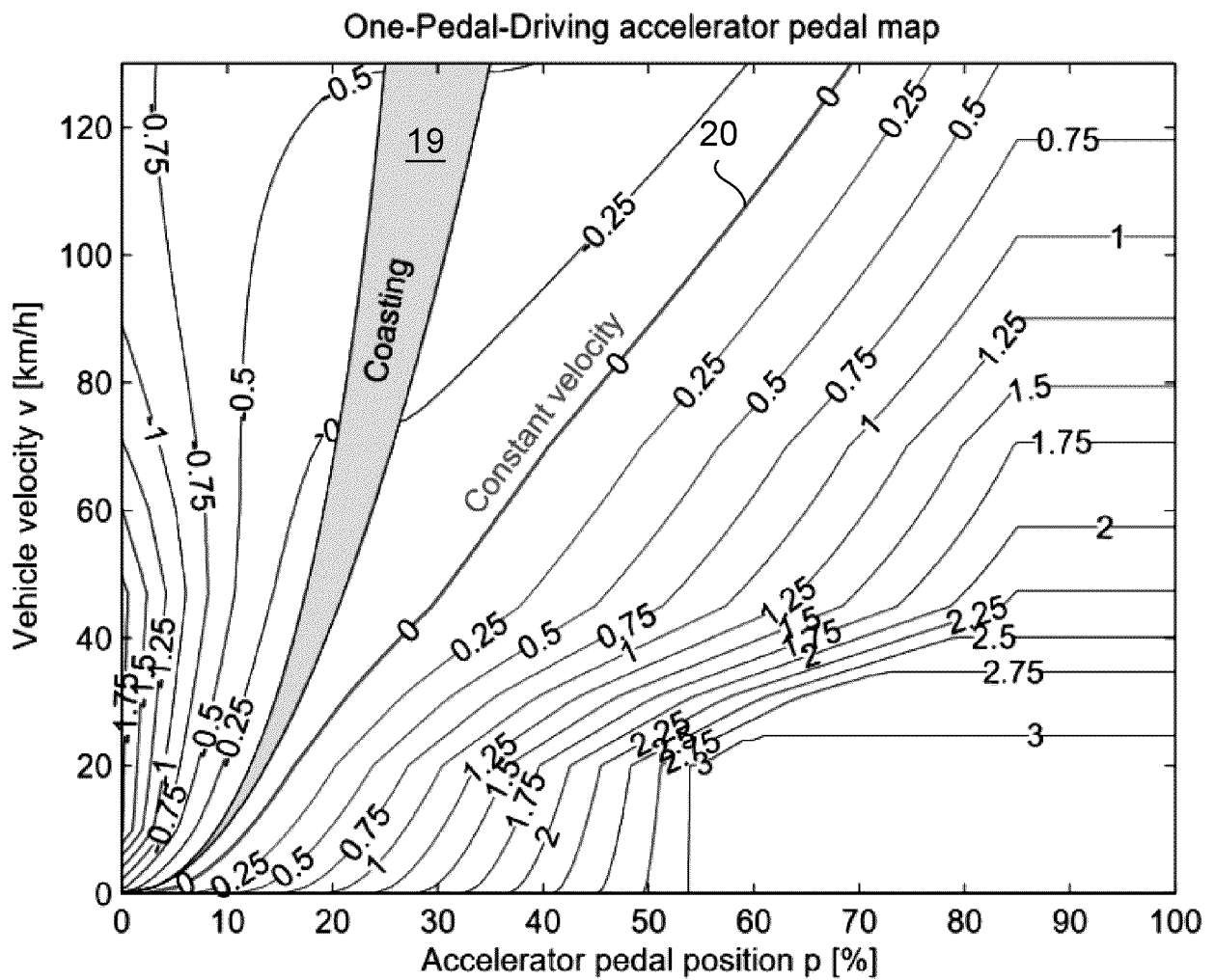


FIG. 3

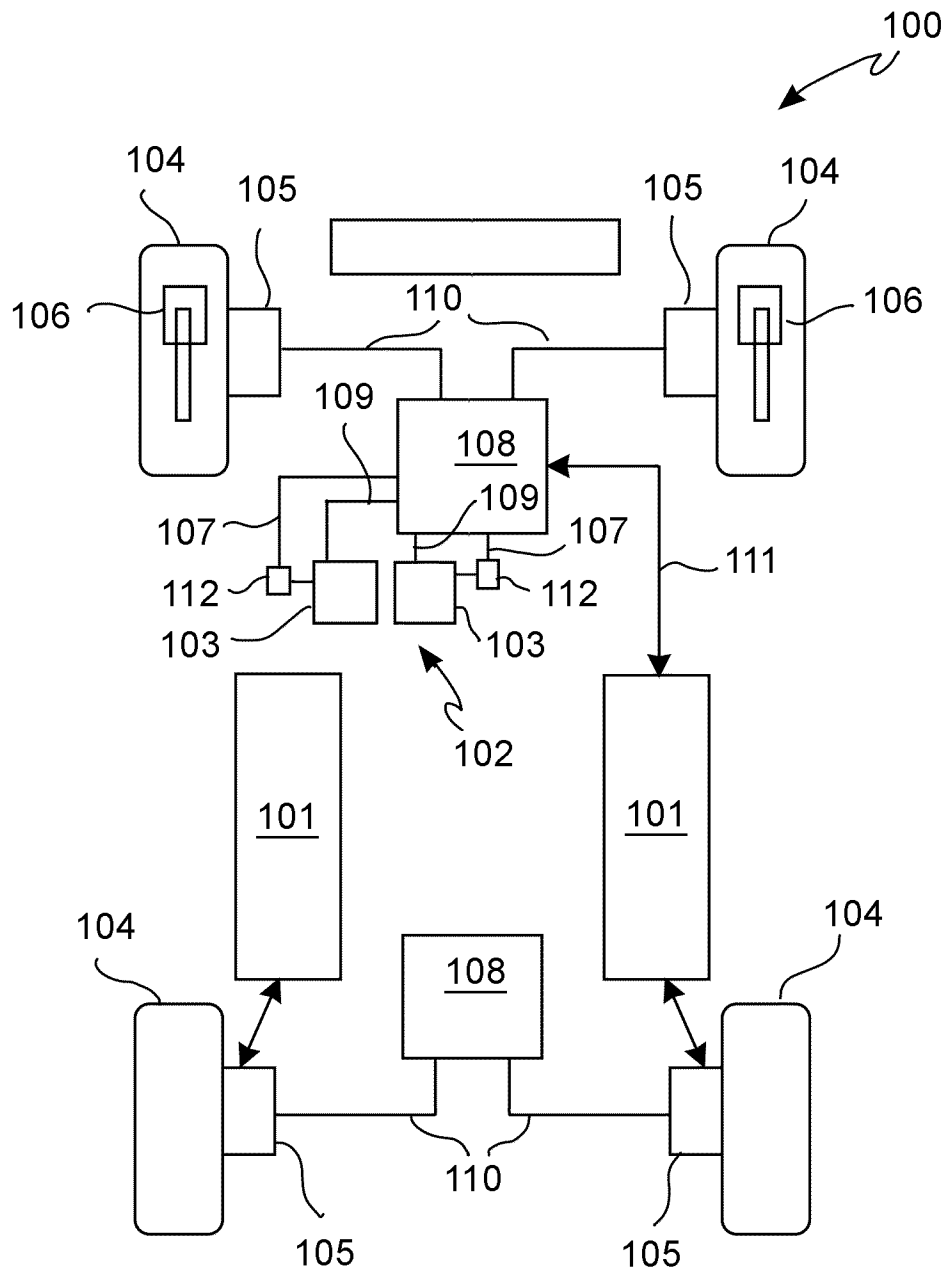


FIG. 4

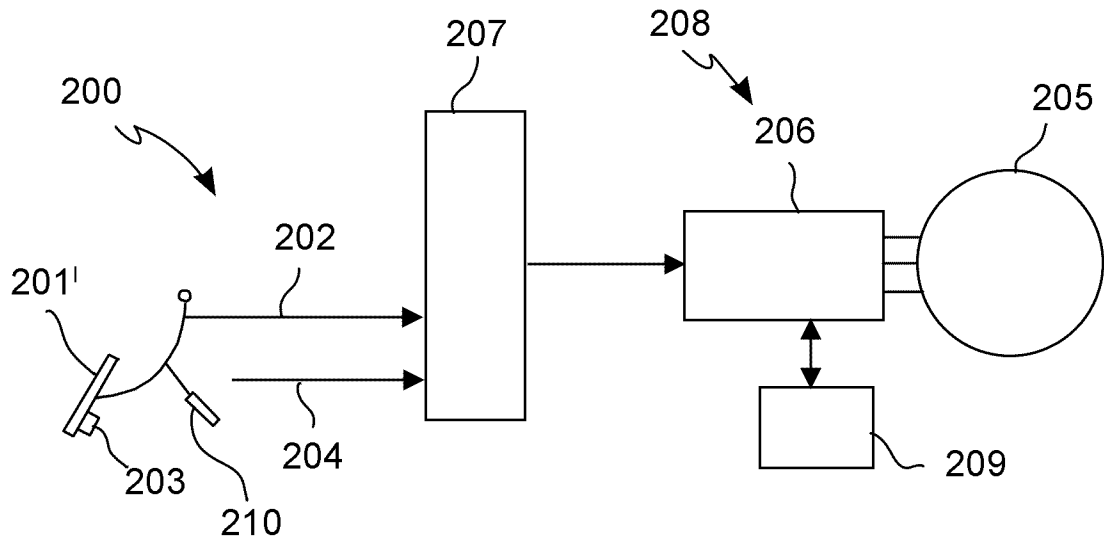


FIG. 5

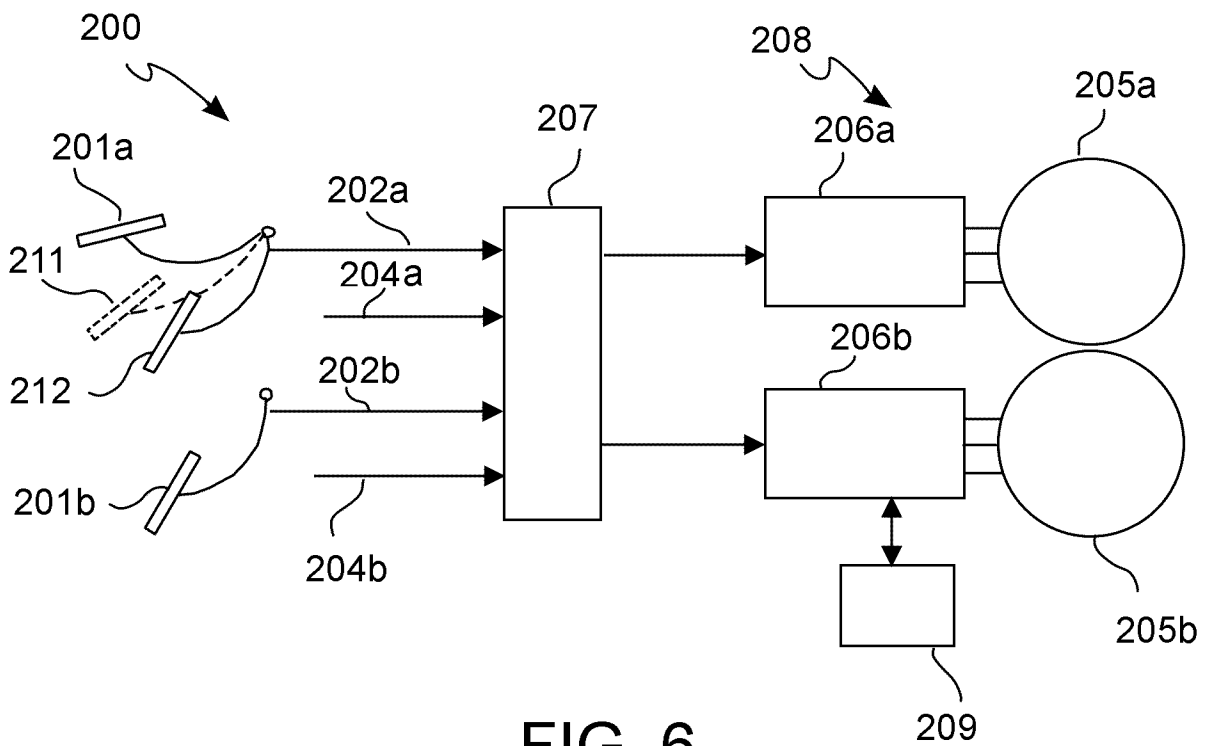


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/066688

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60L7/10 B60L7/24 B60L7/26 B60L15/20
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)

B60L

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

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Y	paragraphs [0011], [0025], [0-30], [0064], [0076] - [0085], [0092], [0093], [0094] - [0100], [0105], [0129], [0130]; figures 1-39	17-36
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Y	US 2020/180432 A1 (GAUTHIER JEAN-PHILIPPE [US]) 11 June 2020 (2020-06-11)	15,16
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	paragraph [0034]; figures 2a-4	

	- / - -	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

28 August 2024

Date of mailing of the international search report

11/09/2024

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Schury, Dominik

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/066688

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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