Title: DRIVE SYSTEM AND METHOD FOR CHARGING OF A BATTERY OF A HYBRID VEHICLE

Abstract: The present invention concerns a drive system and a method of driving a vehicle (1). The drive system comprises a combustion engine (2), a motor control function (26), a gear box (3), an electric machine (9), an energy storage (20) and a planetary gear. The drive system comprises a control unit (18) which is adapted to receive information concerning the charge level (q) of the energy storage (20), to determine if the charge level (q) is lower than a limit level (qL) when the energy storage has a charging need and if this is the case, control the motor control function (26) such that the combustion engine (2) obtains an increased rotation speed (nL) in relation to the rotation speed (nQ) when the energy storage (20) does not have any charging need.
DRIVE SYSTEM AND METHOD FOR CHARGING OF A BATTERY OF A HYBRID VEHICLE

BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention concerns a drive system according to the preamble of claim 1 and a method of driving a vehicle according to the preamble of claim 11.

To use a conventional clutch mechanism which disconnects the input shaft of the gear box from the combustion engine during gear changing processes in the gear box involves disadvantages. When a stationary vehicle starts, the discs of the clutch mechanism slide against each other. Thereby heating of the discs is provided. This heating results in an increased fuel consumption and a wear of the clutch discs. A conventional clutch mechanism is also relatively heavy and expensive. It occupies also a relatively large space in the vehicle. To use a hydraulic moment converter also results in losses.

Hybrid vehicles can be driven by a primary motor which can be a combustion engine and a secondary motor which can be an electric machine. The electric machine is equipped with at least one energy storage for storing electric energy and control equipment for controlling the flow of electric energy between the energy storage and the electric machine. The electric machine can thereby alternately work as motor and generator in dependence on the operation state of the vehicle. When the vehicle is braked, the electric machine generates electric energy which is stored in the energy storage. The stored electric energy is used later, for example, for driving the vehicle and operating different auxiliary systems in the vehicle.

The Swedish patent application SE 1051384-4, which has not been made public, shows a hybrid drive system with a planetary gear which comprises three components, namely a sun wheel, a planet wheel holder and a ring wheel. One of the three components of the planetary gear is connected to an output shaft of the combustion engine, a second component of the planetary gear is connected to an input shaft to the gear box and a third component of the planetary gear is connected to a rotor of an electric machine. The electric machine is connected to an energy storage such that it alternately can work as motor and generator. The rotation speed of electric machines can be controlled in a stepless manner. By controlling the rotation speed of the electric machine, the input shaft to the gear box can be given a desired rotation speed. With a
hybrid system according to SE 1051384-4 no clutch mechanism needs to be used in the drive line of the vehicle.

With such a hybrid system, no clutch mechanism needs to be used in the drive line of the vehicle. When the vehicle is driven at a low speed during a longer period, such as during shunting, there is however a risk that the charge level of the energy storage becomes very low or that it is completely discharged.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a drive system for a vehicle of the initially mentioned kind, where the charge level can be maintained in the energy storage even when the vehicle is driven at a low speed during a longer period.

This object is achieved with the drive system of the initially mentioned kind, which is characterized by the features which are specified in the characterizing portion of claim 1. According to the invention, a control unit receives information concerning the charge level of the energy storage and determines if the charge level is lower than a limit level when the energy storage has a charging need. If the charge level is lower than the limit level, the rotation speed of the engine is increased in relation to the rotation speed when the energy storage has a charging need. The rotation speed of the combustion engine is increased to a value such that the charge level of the energy storage at least is prevented from sinking below a lowest acceptable level. Alternatively, the rotation speed of the combustion engine can be increased such that the charge level of the energy storage at least does not sink further. In this case, only the combustion engine is responsible for the operation of the vehicle. However, with advantage, the rotation speed of the combustion engine is increased such that it both can operate the vehicle and the electric machine, which results in that electric energy can be generated in the energy storage. When the charge level of the energy storage has increased above the limit level, the rotation speed of the combustion engine can be reduced again to a normal value.

According to an embodiment of the present invention, the control unit is adapted to receive information about the charge level of the energy storage when the vehicle has a lower speed than a predetermined speed and to determine if the charge level is lower than said limit level for normal operation of the vehicle. During a starting process of
the vehicle, the electric machine initially rotates with a negative rotation speed such that the energy storage is charged. After that the vehicle has started to roll, the vehicle obtains relatively soon a speed at which the electric machine must supply electric energy in order for the speed of the vehicle to be able to increase further. Shunting of heavy vehicles means normally that the vehicle is driven short distances with a low speed between start and stop. The vehicle is continuously driven with an engaged starting gear and the combustion engine works at idle running rotation speed. The electric machine is here responsible for a large part of the operation, which results in that electric energy is converted and that the charge level of the energy storage sinks between each start and stop. During many such consecutive start and stops or continuous shunting, the energy storage risks being discharged completely. If the control unit receives information which indicates that the charge level of the energy storage is below the limit level when the vehicle is driven with a speed below said predetermined speed, it increases the rotation speed of the combustion engine to a higher level than the idle running rotation speed. The rotation speed of the combustion engine is with advantage increased to a value such that it itself can be responsible for the operation of the vehicle. It is thereby prevented that the charge level of the energy storage at least does not sink below a lowest acceptable charge level. With advantage, the rotation speed of the combustion engine is increased to a value such that it also charges the energy storage during operation.

According to an embodiment of the present invention, the control unit is adapted to control the rotation speed of the combustion engine when the charge level is lower than said limit level such that the rotor of the electric machine obtains a direction of rotation at which it charges the energy storage. At a start of the vehicle, the rotor of the electric machine rotates initially with a negative rotation speed such that electric energy is supplied to the energy storage. When the vehicle starts rolling, the input shaft to the gear box obtains a successively increasing rotation speed which reduces the negative rotation speed of the rotor of the electric machine when the rotation speed of the combustion engine is held constant. By increasing the rotation speed of the combustion engine concurrently with that the vehicle obtains an increased speed, the time during which the rotor of the electric machine rotates in a negative direction can be prolonged. The energy storage can thereby be charged during a relatively long time period after that the vehicle has started.
According to another preferred embodiment of the invention, the control unit is adapted to, at occasions when the charge level of the energy storage is lower than said limit level, grade the low charge level of the energy storage and increase the rotation speed of the combustion engine in dependence on this gradation. Such a gradation may, for example, be expressed in the difference/ratio or the like between the charge level of the energy storage and the limit level. Alternatively, the gradation may be done in several gradation steps, for example, low and very low charge level. In this case, the rotation speed of the combustion engine is increased more when the charge level of the energy storage is very low than at occasions when it is only low.

According to another preferred embodiment of the invention, the control unit is adapted to control the rotation speed of the combustion engine when the charge level is lower than the limit level with an increased rotation speed which is related to the rotation speed of the input shaft of the gear box. For a driver of the vehicle, it is important to feel that the operation of the vehicle follows the movements of the accelerator pedal. In this case, the combustion engine obtains an increased rotation speed when the speed of the vehicle increases. The difference that a driver experiences with such an operation in relation to an operation with a conventional vehicle is substantially only that the vehicle is driven with a lower gear than the gear engaged in the gear box. The control unit can be adapted to control the combustion engine with an increased rotation speed which is related to a factor times the rotation speed of the input shaft of the gear box. The magnitude of the factor depends on the charge level of the energy storage. At a very low charge level in the energy storage, a higher factor is used than if the charge level is only low. As the charge level increases, also the factor can be corrected.

According to an alternative embodiment of the present invention, the control unit is adapted to control the rotation speed of the combustion engine when the charge level is lower than the limit level with an increased rotation speed which is related to the demanded driving moment of the vehicle. In this case, the rotation speed of the combustion engine is increased concurrently with the fact that the driver presses down the accelerator pedal. During a normal starting process of the hybrid vehicle, the rotation speed of the combustion engine is initially substantially constant independently of the position of the accelerator pedal. The control unit can be adapted to control the combustion engine with an increased rotation speed which is related to a factor times the demanded driving moment of the vehicle. The magnitude of the factor
depends also here on the charge level of the energy storage. At a very low charge level in the energy storage, a higher factor is used than if the charge level is only low. Also here, said factor may be corrected when the charge level in the energy storage is changed.

According to a further alternative embodiment of the present invention, the control unit is adapted to control the combustion engine with an increased rotation speed which is related to a combination of the rotation speed of the input shaft of the gear box and the demanded driving moment of the vehicle. In this case, the combustion engine is controlled with an increased rotation speed which is determined by a combination of the two alternatives. With advantage, also here a factor is used which is related to the charge level in the energy storage.

According to another preferred embodiment of the invention, the output shaft of the combustion engine is connected to the sun wheel of the planetary gear, the input shaft of the gear box is connected to the planet wheel holder of the planetary gear and the rotor of the electric machine is connected to the ring wheel of the planetary gear. With such a design, the included components may be given a compact construction. The sun wheel and the planet wheel holder may be connected to the output shaft of the combustion engine and the input shaft of the gear box, respectively, with the help of spline joints or the like. It is thereby guaranteed that the sun wheel rotates with the same rotation speed as the output shaft of the combustion engine and that the planet wheel holder rotates with the same rotation speed as the input shaft of the gear box. The rotor of the electric machine may be fixedly arranged on an external peripheral surface of the ring wheel. The internal peripheral surface of the ring wheel is normally provided with cogs. The external peripheral surface of the ring wheel is normally smooth and very well suited for carrying the rotor of the electric machine. The ring wheel and the rotor of the electric machine thereby form a rotatable unit. Alternatively, the rotor of the electric machine may be connected to the ring wheel via a transmission. It is however possible to connect the output shaft of the combustion engine, the input shaft of the gear box and the rotor of the electric machine with any of the other components of the planetary gear.

The initially mentioned object is achieved also by the method according to claims 11-20.
SHORT DESCRIPTION OF THE DRAWINGS

In the following preferred embodiments of the invention are described, as examples, with reference to the annexed drawings, on which:

Fig 1 shows a drive line of a vehicle with a drive system according to the present invention,
Fig 2 shows the drive system in more detail,
Fig 3 shows how different parameters can vary during a starting process of the vehicle in a normal operation,
Fig 4 shows how different parameters can vary during a starting process of the vehicle in an operation in order to maintain the charge of the energy storage and
Fig 5 shows how the charge level of the energy storage can vary during shunting.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Fig 1 shows a drive line for a heavy vehicle 1. The drive line comprises a combustion engine 2, a gear box 3, a number of drive shafts 4 and drive wheels 5. Between the combustion engine 2 and the gear box 3 the drive line comprises an intermediate part 6. Fig 2 shows the components in the intermediate part 6 in more detail. The combustion engine 2 is provided with an output shaft 2a and the gear box 3 with an input shaft 3a in the intermediate part 6. The output shaft 2a of the combustion engine is coaxially arranged in relation to the input shaft 3a of the gear box. The output shaft 2a of the combustion engine and the input shaft 3a of the gear box are rotatably arranged around a common axis of rotation 7. The intermediate part 6 comprises a housing 8 which encloses an electric machine 9 and a planetary gear. The electric machine 9 comprises in a customary manner a stator 9a and a rotor 9b. The stator 9a comprises a stator core which is attached in a suitable manner on the inside of the housing 8. The stator core comprises the windings of the stator. The electric machine 9 is adapted to during certain operation occasions use stored electric energy for supplying drive power to the input shaft 3a of the gear box and to during other operation occasions use the kinetic energy of the input shaft 3 of the gear box for generating and storing electric energy.
The planetary gear is arranged substantially radially inside of the stator 9a and rotor 9b of the electric machine. The planetary gear comprises in a customary manner a sun wheel 10, a ring wheel 11 and a planet wheel holder 12. The planet wheel holder 12 carries a number of cog wheels 13 which are rotatably arranged in a radial space between the cogs of the sun wheel 10 and the ring wheel 11. The sun wheel 10 is attached on a peripheral surface of the output shaft 2a of the combustion engine. The sun wheel 10 and the output shaft 2a of the combustion engine rotate as a unit with a first rotation speed n1. The planet wheel holder 12 comprises an attachment portion 12a which is attached on a peripheral surface of the input shaft 3a of the gear box with the help of a spline joint 14. With the help of this joint, the planet wheel holder 12 and the input shaft 3a of the gear box can rotate as a unit with a second rotation speed n2. The ring wheel 11 comprises an external peripheral surface on which the rotor 9b is fixedly mounted. The rotor 9b and the ring wheel 11 constitute a rotatable unit which rotates with a third rotation speed n3.

Since the intermediate part 6 between the combustion engine 2 and the gear box 3 in a vehicle is limited, it is required that the electric machine 9 and the planetary gear constitute a compact unit. The components 10-12 of the planetary gear are here arranged substantially radially inside of the stator 9a of the electric machine. The rotor 9b of the electric machine, the ring wheel 11 of the planetary gear, the output shaft 2a of the combustion engine and the input shaft 3a of the gear box are here rotatably arranged around a common axis of rotation 5. With such a design, the electric machine 9 and the planetary gear occupy a relatively small space.

The vehicle comprises a locking mechanism which is movable between a first open position in which the three components 10-12 of the planetary gear are allowed to rotate with different rotation speeds and a second locked position in which it locks together two of the components 10, 12 of the planetary gear such that the three components 10-12 of the planetary gear rotate with the same rotation speed. In this embodiment, the locking mechanism comprises a displaceable coupling member 15. The coupling member 15 is attached on the output shaft 2a of the combustion engine with the help of a spline joint 16. The coupling member 15 is in this case arranged, secured against turning, on the output shaft 2a of the combustion engine and displaceably arranged in an axial direction on the output shaft 2a of the combustion engine. The coupling member 15 comprises a coupling portion 15a which is
connectable to a coupling portion 12b of the planet wheel holder 12. The locking mechanism comprises a schematically shown displacement member 17 is adapted to displace the coupling member 15 between the first free position 11 when the coupling portions 15a, 12b are not in engagement with each other and the second locked position 12 when the coupling portions 15a, 12b are in engagement with each other. In the first open position, the output shaft 2 of the combustion engine and the input shaft 3 of the gear box can rotate with different rotation speeds. When the coupling portions 15a, 12b are in engagement with each other, the output shaft 2 of the combustion engine and the input shaft 3 of the gear box will rotate with the same rotation speed.

An electric control unit 18 is adapted to control the displacement member 17. The control unit 18 is also adapted to decide at which occasions the electric machine 9 is to work as motor and at which occasions it is to work as generator. In order to decide this, the control unit 18 can receive actual information from suitable operation parameters. The control unit 18 can be a computer with a suitable software for this purpose. The control unit 18 also controls a schematically shown control equipment 19 which controls the flow of electric energy between an energy storage 20 and the stator 9a of the electric machine. At occasions when the electric machine 9 works as motor, stored electric energy from the energy storage 20 is supplied to the stator 9a. At occasions when the electric machine works as generator, electric energy from the stator 9a is supplied to the energy storage 20. The energy storage 20 delivers and stores electric energy with a rated output in the order of 200-800 Volt. The control unit 18 receives information from a measurement instrument 21 concerning the charge level q of the energy storage. The control unit 18 receives information from a sensor 22 which senses the position an accelerator pedal. The position of the accelerator pedal corresponds to the driving moment that the driver wishes to supply to the vehicle 1. The vehicle 1 is equipped with a motor control function 26 with which the rotation speed n1 of the combustion engine can be controlled. The control unit 18 has, for example, the possibility to activate the motor control function 26 during engagement and disengagement of gears in the gear box 3 in order to create a momentless state in the gear box 3.

Fig. 3 shows a starting process of the vehicle where the control unit 18 has received information from the measurement instrument 21 which indicates that the charge level q of the battery is equal to or higher than a limit level q0 which the energy storage 20 should have during the start in order for the vehicle 1 to be able to be started in a
normal manner. The control unit 18 will thereby carry out a normal start of the vehicle and control the motor control function 26 such that the combustion engine 2 maintains its idle running rotation speed during the starting process. Fig. 3 shows in the form of curves how the rotation speed \( n_1 \) of the output shaft of the combustion engine, the rotation speed \( n_2 \) of the input shaft of the gear box, the rotation speed \( n_3 \) of the electric machine and the current \( I \) to the energy storage 20 may vary during such a normal starting process of the vehicle 1. The rotation speed \( n_1 \) of the output shaft of the combustion engine is here shown with a continuous line, the rotation speed \( n_2 \) of the input shaft of the gear box is shown with a dotted line, the rotation speed \( n_3 \) of the electric machine is shown with a dashed-dotted line and the current \( I \) to the energy storage 20 is shown with a dashed line. The ratio between the number of cogs \( z_1 \) of the sun wheel 9 and the number of cogs \( z_2 \) of the ring wheel 10 is in this example \( z_1/z_2 = 0.7 \).

At \( t = 0 \), the combustion engine 2 has started and is operated with an idle running rotation speed which in this case is 500 rpm. The input shaft 3a of the gear box is not rotating and has thus an initial rotation speed \( n_2 = 0 \) rpm. Since all the components in the planetary gear are connected to each other with a predetermined transmission ratio, the ring wheel 11 initially obtains a rotation speed \( n_3 \) which is determined by the two other rotation speeds \( n_1, n_2 \). With the above mentioned transmission ratio \( z_1/z_2 = 0.7 \), the ring wheel obtains that rotation speed \( n_3 = 350 \) rpm. The ring wheel 11 thus initially rotates in an opposite direction in relation to the sun wheel 10. The control unit 18 controls the control mechanism 19 such that the electric machine 9 provides a moment which brakes the ring wheel 11. Thereby electric energy is generated and current \( I \) is initially led from the electric machine 9 to the energy storage 20. The input shaft 3a of the gear box obtains a driving moment which is determined by the moment of the combustion engine and the braking moment of the electric machine. This moment will act on the input shaft 3a of the gear box such that it starts to rotate, i.e. \( n_2 \) becomes larger than zero and the vehicle 1 starts.

The control unit 18 receives information from the sensor 22 concerning the position of the accelerator pedal and controls the control mechanism 19 such that the electric machine and the combustion engine supply a moment to the input shaft 3a of the gear box such that the vehicle 1 obtains the by the position of the accelerator pedal indicated driving moment. The control unit 18 controls the engine rotation speed function 26 such that the rotation speed \( n_1 \) of the combustion engine is held constant.
When the rotation speed $n_2$ of the input shaft of the gear box increases, this results in that the negative rotation speed $n_3$ of the electric machine 9 is reduced when the rotation speed $n_1$ of the combustion engine at the same time is constant. At the time $t_a$, the rotation speed $n_2$ of the input shaft of the gear box has increased to a value such that the negative rotation speed $n_3$ of the electric machine has been completely eliminated. The time $t_a$ may be in the order of magnitude of 0.5 seconds. During the continued operation, the rotor 11 of the electric machine rotates with a positive rotation speed $n_3$. Electric energy from the energy storage 20 will thereby be consumed and a current $I$ is led from the energy storage 20 to the electric machine 9. After that the time $t_a$ has been passed, the current $I$ which is led from the energy storage to the electric machine 9 increases with the rotation speed $n_2$ of the input shaft of the gear box and the speed of the vehicle. At the time $t_b$, approximately the same current has been consumed as has initially been generated in the energy storage 20 during the starting process. The time $t_b$ may be in the order of magnitude of 1 second. During the continued operation of the vehicle with the combustion engine 2 at an idle running rotation speed and with engaged starting gear, a relatively large amount of electric energy is consumed. If the vehicle 1 during a longer period is operated in such an operation condition, the charge level of the energy storage sinks substantially. This may, for example, be the case during shunting when the vehicle 1 is driven short distances at a low speed between start and stop. If a normal operation is used, there is a risk that the energy storage 20 discharges completely.

Fig. 4 shows a starting process of the vehicle where the control unit 18 has received information from the measurement instrument 21 which indicates that the charge level $q$ of the battery is lower than the limit level $q_0$ that the energy storage 20 should have during the start in order for the vehicle to be able to be started and operated in a normal manner. The energy storage 20 has a charging need since the charge level $q$ is below the limit level $q_0$. The control unit 18 also notes how much lower the charge level $q$ is than the limit level $q_0$. In a corresponding manner as in Fig. 3, the combustion engine 2 has at $t = 0$ an idle running rotation speed of 500 rpm, the input shaft 3a of the gear box has a rotation speed $n_2 = 0$ rpm and the rotor 9b of the electric machine has a rotation speed $n_3 = -350$ rpm. The control unit 18 will in this case provide an alternative operation of the vehicle 1 in order to maintain that the charge level $q$ of the energy storage.
The control unit 18 receives information from the sensor 22 concerning the position of the accelerator pedal and thereby the driving moment which the driver wishes to supply to the vehicle 1. With the help of this information, the control unit 18 controls the control mechanism 19 and the motor control function 26 such that the electric machine 9 and the combustion engine 2 gives the input shaft of the gear box a moment which corresponds to the desired driving moment of the vehicle 1. In this case, the control unit 18 controls the motor control function 26 such that the combustion engine 2 obtains an increased rotation speed \( n_{1s} \) which is related to a factor times the rotation speed \( n_2 \) of the input shaft of the gear box and the speed of the vehicle with engaged gear in the gear box 3. The magnitude of said factor depends on how low the charge level \( q \) of the energy storage is in relation to the limit level \( q_0 \). At a charge level \( q \) in the energy storage 20 which is clearly below the limit level \( q_0 \), a higher factor is used than if the charge level \( q \) in the energy storage 20 is more marginally below the limit level \( q_0 \). Since the rotation speed \( n_1 \) of the combustion engine increases with the rotation speed \( n_2 \) of the input shaft of the gear box, the negative rotation speed \( n_3 \) of the rotor 9b of the electric machine can be maintained during a longer time period than the time \( t_0 \). Current I is thereby supplied to the energy storage 20 during a prolonged time period which results in that the charge level \( q \) in the energy storage 20 increases. The relation between the rotation speed \( n_1 \) of the combustion engine and the increased speed of the vehicle is experienced as natural by the driver.

Alternatively, the control unit 18 may control the motor control function 26 such that the combustion engine obtains an increased rotation speed \( n_{1s} \) which is related to a factor times the demanded driving moment of the vehicle. The magnitude of said factor depends also in this case on how low the charge level \( q \) of the energy storage is in relation to the limit level \( q_0 \). If the driver wishes to drive the vehicle with a constant driving moment, the rotation speed \( n_1 \) of the combustion engine can also in this case increase with time in a corresponding manner as is shown in Fig. 4. Also in this case, the negative rotation speed \( n_3 \) of the rotor 9b of the electric machine is maintained during a longer time period than until the time \( t_0 \). Current I is thus led during a longer time period from the electric machine 9 to the energy storage 20, which results in that the charge level \( q \) of the energy storage 20 is increased. In this case, the rotation speed of the combustion engine increases as the accelerated pedal is pressed down, which is also experienced as natural by a driver. The experience in this case will be the same as at a start with a heavy load of a conventional vehicle, where the rotation speed is
increased if the moment of the combustion engine 2 when running idle is not sufficient for starting the vehicle 1.

According to a further alternative, the control unit 18 may control the motor control function 26 such that the combustion engine obtains an increased rotation speed \( n_{1\ast} \), which is both related to a factor times the rotation speed \( n_2 \) of the input shaft of the gearbox and a factor times the demanded driving moment of the vehicle. To determine the increased rotation speed \( n_{1\ast} \) of the combustion engine by means of a factor times the rotation speed \( n_2 \) of the input shaft of the gearbox may be termed as a first method.

To determine the increased rotation speed \( n_{1\ast} \) of the combustion engine by means of a factor times the demanded driving moment of the vehicle may be termed as a second method. In this case, may, for example, whichever of the two methods resulting in the highest value of the increased rotation speed \( n_{1\ast} \) to be controlling during prevailing operation occasions. It is also possible that a linear combination of the two methods is used to determine the increased rotation speed \( n_{1\ast} \) of the combustion engine. With a linear combination means that the increased rotation speed \( n_{1\ast} \) of the combustion engine is determined by means of a weighted combination of the two methods. The increased rotation speed \( n_{1\ast} \) of the combustion engine may, for example, be determined to 40% of one of the methods and to 60% by the other method. The ratio between the methods may vary during different operational conditions.

Fig. 5 shows how the charge level \( q \) of the energy storage may change during a shunting operation of the hybrid vehicle 1. The charge level \( q_{\text{min}} \) means that the energy storage is almost completely discharged. The charge level \( q_{\text{min}} \) must under all circumstances be maintained. At the time \( t = 0 \), the vehicle 1 starts. The control unit 18 receives in this case information from the measurement instrument 21 which indicates that the charge level \( q \) of the energy storage 20 clearly exceeds the limit level \( q_0 \). The vehicle 1 can thereby be started and operated in a normal manner. During the operation process, the charge level of the energy storage 20 increases initially and will then sink to a lower charge level at the time \( t_1 \) when the driver stops the vehicle. The charge level \( q \) of the energy storage 20 follows a substantially correspondingly shaped curve as the current curve I Fig. 3. At the time \( t_1 \), the vehicle 1 starts again. The control unit 18 receives information from the measurement instrument 21 which indicates that the charge level \( q \) of the energy storage 20 still exceeds the limit level \( q_0 \). The vehicle 1 can thereby also in this case be started and driven in a normal manner. The vehicle 1 is stopped and starts thereafter substantially directly again at the time \( t_2 \) and the
procedure according to the above is repeated. It can be noticed that the charge level $q$ of the energy storage sinks successively for each start and stop of the vehicle during normal operation when the vehicle $1$ is driven at a low speed and with engaged starting gear. When the vehicle $1$ is to start at the time $t_3$, the charge level $q$ of the energy storage $20$ has sunk to a lower level than the limit level $q_0$. The control unit $18$ estimates how much lower the charge level $q$ is than the limit level $q_0$. The control unit $18$ controls the combustion engine $2$ with an increased rotation speed $n_{1\text{,rot}}$ which is related to a factor $f$ times the rotation speed $n_2$ of the input shaft of the gear box or a demanded driving moment of the vehicle. Said factor is thus related to how much lower the charge level $q$ is than the limit level $q_0$. In this case, the charge level of the energy storage $20$ is increased in a corresponding manner as at a normal start. The charge level $q$ of the battery here follows a substantially correspondingly shaped curve as the current curve $1$ in Fig. 4. The charge level $q$ of the energy storage increases initially to a level above the limit level $q_0$, after which it falls down to the limit level $q_0$. The vehicle stops and starts again at $t_4$. The control unit $18$ can correct said factor during the operation when the charge level $q$ of the energy storage $20$ changes in relation to the limit level $q_0$.

At $t_4$, the energy storage $20$ has a charge level $q$ which corresponds to the limit level $q_0$. The vehicle $1$ is thereby given a normal start. The charge level increases initially, after which it sinks down towards the limit level $q_0$. In this case, the charge level of the energy storage is prevented from sinking below the limit level $q_0$. The control unit $18$ receives in this case continuously information from the measurement instrument $21$. When the control unit $18$ receives information which indicates that the charge level $q$ of the energy storage has sunk down to the limit level $q_0$, the control unit $18$ increases the rotation speed $n_{1\text{,rot}}$ of the combustion engine such that the charge level $q$ of the energy storage does not sink further. Thereafter, the control unit $18$ controls the rotation speed of the combustion engine such that the charge level does not fall under the limit level $q_0$. As soon as the vehicle reaches a speed $v_2$ at which the coupling member can be displaced to the first position, the energy storage can be charged by the combustion engine $2$ since it in this position is connected to the electric machine $9$.

The invention is in no way limited to the embodiment described on the drawings but can be varied freely within the scope of the claims. For example, a transmission with a gear ratio can be arranged between the rotor $9$ and the ring wheel $11$. The rotor $9$ and the ring wheel $11$ need thus not rotate with the same rotation speed.
Claims

1. Drive system for a vehicle (1), wherein the drive system comprises a combustion engine (2) with an output shaft (2a), a motor control function (26) which enables control of the rotation speed of the combustion engine, a gear box (3) with an input shaft (3a), an electric machine (9) which comprises a stator (9a) and a rotor (9b), an energy storage (20) which is connected to the electric machine (9) and a planetary gear which comprises a sun wheel (10), a ring wheel (11) and a planet wheel holder (12), wherein the output shaft (2a) of the combustion engine is connected to a first of said components of the planetary gear such that a rotation of this shaft (2a) leads to a rotation of this component, wherein the input shaft (3a) of the gear box is connected to a second of said components of the planetary gear such that a rotation of this shaft leads to a rotation of this component and the rotor (9b) of the electric machine is connected to a third of said components of the planetary gear such that a rotation of the rotor leads to a rotation of this component, characterized in that the drive system comprises a control unit (18) which is adapted to receive information concerning the charge level (q) of the energy storage (20), to determine if the charge level (q) is lower than a limit level (q₀) at which the energy storage (20) has a charging need and if this is case control the motor control function (26) such that the combustion engine (2) obtains an increased rotation speed (n₁) in relation to the rotation speed (n₂) when the energy storage (20) does not have any charging need.

2. Drive system according to claim 1, characterized in that the control unit (18) is adapted to receive information about the charge level (q) of the energy storage (20) when the vehicle (1) has a lower speed than a predetermined speed (v₂) and to determine if the charge level (q) is lower than said limit level (q₀) for the start of the vehicle during normal operation.

3. Drive system according to claim 1 or 2, characterized in that the control unit (18) is adapted to control the rotation speed (n₁) of the combustion engine when the charge level (q) is lower than said limit level (q₀) such that the rotor (9b) of the electric machine obtains a direction of rotation at which it charges the energy storage (20).

4. Drive system according to any of the preceding claims, characterized in that the control unit (18) is adapted to, at occasions when the charge level of the energy storage (20) is lower than said limit level (q₀), grade the low charge level of the energy storage
(20) and increase the rotation speed of the combustion engine in dependence on this gradation.

5. Drive system according to any of the preceding claims, characterized in that the control unit (18) is adapted to control the rotation speed of the combustion engine when the charge level (q) is lower than said limit level (q0) with an increased rotation speed (n_{1+}) which is related to the rotation speed (n_2) of the input shaft of the gear box.

6. Drive system according to claim 5, characterized in that the control unit (18) is adapted to control the combustion engine (2) with an increased rotation speed (n_{1+}) which is related to a factor (f) times the rotation speed (n_2) of the input shaft of the gear box.

7. Drive system according to any of the preceding claims 1 to 4, characterized in that the control unit (18) is adapted to control the rotation speed of the combustion engine when the charge level (q) is lower than said limit level (q_0) with an increased rotation speed (n_{1+}) which is related to the demanded driving moment of the vehicle (1).

8. Drive system according to claim 7, characterized in that the control unit (18) is adapted to control the combustion engine (2) with an increased rotation speed (n_{1+}) which is related to a factor (f) times the demanded driving moment of the vehicle (1).

9. Drive system according to claim 5 and 7, characterized in that the control unit (18) is adapted to control the combustion engine (2) with an increased rotation speed (n_{1+}) which is related to a combination of the rotation speed (n_2) of the input shaft of the gear box and the driver’s demanded driving moment of the vehicle (1).

10. Drive system according to any of the preceding claims, characterized in that the output shaft (2a) of the combustion engine is connected to the sun wheel (10) of the planetary gear, that the input shaft (3a) of the gear box is connected to the planet wheel holder (12) of the planetary gear and that the rotor (9b) of the electric machine is connected to the ring wheel (11) of the planetary gear.

11. Method of driving a vehicle (1), wherein the vehicle comprises a combustion engine (2) with an output shaft (2a), a motor control function which enables control of the rotation speed of the combustion engine, a gear box (3) with an input shaft (3a), an
electric machine (9) which comprises a stator (9a) and a rotor (9b), an energy storage (20) which is connected to the electric machine (9) and a planetary gear which comprises a sun wheel (10), a ring wheel (11) and a planet wheel holder (12), wherein the output shaft (2a) of the combustion engine is connected to a first of said components of the planetary gear such that a rotation of this shaft (2a) leads to a rotation of this component, wherein the input shaft (3a) of the gear box is connected to a second of said components of the planetary gear such that a rotation of this shaft leads to a rotation of this component and the rotor (9b) of the electric machine is connected to a third of said components of the planetary gear such that a rotation of the rotor leads to a rotation of this component, characterized by the steps to receive information concerning the charge level (q) of the energy storage (20), to determine if the charge level (q) is lower than a limit level (q₀) at which the energy storage (20) has a charging need and if this is case control the motor control function (26) such that the combustion engine (2) obtains an increased rotation speed (n₁+) in relation to the rotation speed (n₁) when the energy storage (20) does not have any charging need.

12. Method according to claim 11, characterized by the step to receive information about the charge level (q) of the energy storage (20) when the vehicle (1) has a lower speed than a predetermined speed (v₂) and to determine if the charge level (q) is lower than said limit level (q₀).

13. Method according to claim 11 or 12, characterized by the step to control the rotation speed (n₁) of the combustion engine when the charge level (q) is lower than said limit level (q₀) such that the rotor (9b) of the electric machine obtains a direction of rotation at which it charges the energy storage (20).

14. Method according to any of the preceding claims 11-13, characterized by the step to, at occasions when the charge level of the energy storage (20) is lower than said limit level (q₀), grade the low charge level of the energy storage (20) and give the combustion engine an increased rotation speed (n₁+) in dependence on this gradation.

15. Method according to any of the preceding claims 11-14, characterized by the step to control the rotation speed of the combustion engine when the charge level (q) is lower than said limit level (q₀) with an increased rotation speed (n₁-) which is related to the rotation speed (n₂) of the input shaft of the gear box.
16. Method according to claim 15, characterized by the step to control the combustion engine (2) with an increased rotation speed \( (n_{1.2}) \) which is related to a factor \( (f) \) times the rotation speed \( (n_2) \) of the input shaft of the gear box.

17. Method according to any of the preceding claims 11-14, characterized by the step to control the rotation speed of the combustion engine when the charge level \( (q) \) is lower than said limit level \( (q_0) \) with an increased rotation speed \( (n_{1.2}) \) which is related to the demanded driving moment of the vehicle (1).

18. Method according to claim 17, characterized by the step to control the combustion engine (2) with an increased rotation speed \( (n_{1.2}) \) which is related to a factor \( (f) \) times the demanded driving moment of the vehicle (1).

19. Method according to claim 15 and 17, characterized by the step to control the combustion engine (2) with an increased rotation speed \( (n_{1.2}) \) which is related to a combination of the rotation speed \( (n_2) \) of the input shaft of the gear box and the demanded driving moment of the vehicle (1).

20. Method according to any of the preceding claims 11-19, characterized by the steps to connect the output shaft (2) of the combustion engine to the sun wheel (9) of the planetary gear, to connect the input shaft (3) of the gear box to the planet wheel holder (11) of the planetary gear and to connect the rotor (8) of the electric machine to the ring wheel (10) of the planetary gear.

21. Computer program comprising computer program code for making a computer implement a method according to any of the claims 11-20 when the computer program code is executed in the computer.

22. Computer program product comprising a data storage medium which is readable by a computer, wherein the computer program code of a computer program according to claim 21 is stored on the data storage medium.

23. Vehicle comprising a drive system according to any of the claims 1-10.
Fig 3

Fig 4
Fig 5
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: B60K, B60W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 6428438 B1 (BOWEN THOMAS C), 6 August 2002 (2002-08-06); whole document</td>
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  "A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search: 16-10-2013
Date of mailing of the international search report: 17-10-2013

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International Patent Classification (IPC)

B60W 10/26 (2006.01)
B60K 6/365 (2007.10)
B60K 6/445 (2007.10)
B60W 10/06 (2006.01)
B60W 10/08 (2006.01)
B60W 10/115 (2012.01)
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