(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 May 2010 (06.05.2010)

PCT

(10) International Publication Number
WO 2010/050858 A1

(51) International Patent Classification:
H02H 7/09 (2006.01) *H02H 3/20* (2006.01)
B60W 20/00 (2006.01) *H02H 7/085* (2006.01)

(21) International Application Number:
PCT/SE2008/000624

(22) International Filing Date:
3 November 2008 (03.11.2008)

(25) Filing Language: English

(26) Publication Language: English

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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, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Published:

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

WO 2010/050858 A1

(54) **Title**: A METHOD AND DEVICE FOR DECREASING RISK OF ELECTRIC SHOCK FROM A HYBRID ELECTRIC VEHICLE IN CASE OF SYSTEM FAILURE

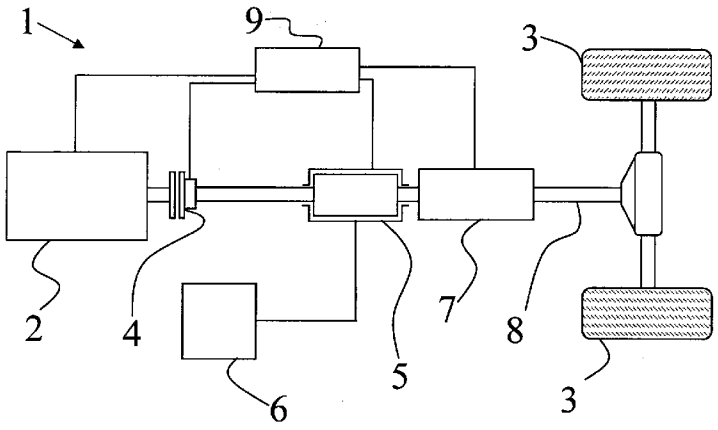

Fig. 1

(57) **Abstract**: A method and device for automatically decreasing risk of electric shock from a hybrid electric vehicle power train (1) in case of system failure, said method comprising the steps of : a. Detecting (21) system failure in said hybrid electric vehicle power train; b. Disconnecting (22) an energy storage device (6) arranged for providing energy to a permanent magnetized electric motor (5) of said hybrid electric vehicle power train; c. Controlling said hybrid electric vehicle power train in such a way as to limit rotational speed of said permanent magnetized electric motor to a rotational speed limit corresponding to an output voltage from said permanent magnetized electric motor below a human hazardous voltage limit.

A method and device for decreasing risk of electric shock from a hybrid electric vehicle in case of system failure

TECHNICAL FIELD OF THE INVENTION:

The present invention relates to a method for decreasing risk of electric shock from a hybrid electric vehicle in case of system failure, in accordance with the preamble of the accompanying claim 1. In particular, the invention will find its application in connection with automotive vehicles, and is intended to be a method for increasing electric security. The invention also relates to a device intended for such electric security increase, in accordance with the preamble of the accompanying claim 7.

The invention also relates to a computer program, a computer program product and a storage medium all to be used in a computer environment.

BACKGROUND OF THE INVENTION:

In a Hybrid Electric Vehicle (HEV) with a permanent magnetized electric motor fixedly mounted on one member of the powertrain gives that the vehicle cannot be propelled by the internal combustion engine without rotating the electric motor. The rotation of the electric motor produces a system voltage. A voltage higher than 60V is regarded as hazardous to human beings if electric live parts are exposed to human beings.

With the relatively high voltage, of up to 1000V, the risk of electric shock follows the introduction of a HEV propulsion system. To deal with this risk the action to a number of possible faults in the HEV propulsion system is to shut these electric components down. That means disconnecting the energy storage

system and disabling the electric motor. However, since the electric motor is permanently magnetized a voltage that is high enough for electric shock (above 60 V) can still be generated when the electric motor is fixedly mounted to one of the propeller shaft members so that it is forced to rotate when the vehicle is propelled. This voltage passes the power electronics of the electric motor and reaches a DC link (the conductive network between the energy storage and the electric motor and any other connected electric components). This means that even though the HEV components are shut off the sheer rotation of the electric motor implicates a risk for electric shock.

To avoid the risk of obtaining electric shock when a system failure in the electric propulsion system occurs, the vehicle is forced to stop and the mission is aborted. The cause of the system failure with an exposed hazardous voltage can be, for example, a loose cable connector, an opened component hatch or isolation resistance problem. The exposed hazardous voltage can be detected by a detection mechanism. The action is to disconnect the energy storage (battery or super capacitor) in order to prevent the electric motor to rotate, which means that the vehicle is stopped. This means that the vehicle cannot be propelled, not even to the side of the road or from a potentially dangerous position.

A technical problem addressed by the present invention is therefore to provide a more advanced electric security arrangement in a HEV, which increases the flexibility of the vehicle when a system failure has occurred.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an improved HEV which is capable of increase the

movability of the vehicle during said system failure, still with maintained electric security.

This object is addressed by a method for automatically decreasing risk of electric shock from a hybrid electric vehicle power train in case of system failure as defined in appended claim 1. According to a first aspect of the invention, said method comprises (includes, but is not necessarily limited to) the steps of:

a. Detecting system failure in said hybrid electric vehicle power train;
b. Disconnecting an energy storage device arranged for providing energy to a permanent magnetized electric motor of said hybrid electric vehicle power train;
c. Controlling said hybrid electric vehicle power train in such a way as to limit rotational speed of said permanent magnetized electric motor to a rotational speed limit corresponding to an output voltage from said permanent magnetized electric motor below a human hazardous voltage limit.

According to one embodiment of the method according to the invention, said method is characterized in that said step c comprising control of engagement of a master clutch of said powertrain with a clutch slip in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

According to a further embodiment of the method according to the invention, said method is characterized in that said step c comprising lowering of idle speed of a combustion engine of said powertrain in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

According to another embodiment of the method according to the invention, said method is characterized in that said step c comprising both control of said engagement of said master clutch and said lowering of said idle speed in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

According to one embodiment of the method according to the invention, said method is characterized in that said step c comprising controlling in the first place lowering of said idle speed and additionally in the second place when needed performing control of said engagement of said master clutch.

Said object is also addressed by a device for a hybrid electric vehicle powertrain.

Further advantageous embodiments of the invention emerge from the dependent patent claims following patent claim 1.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will be described in greater detail below with reference to the accompanying drawing which, for the purpose of exemplification, shows further preferred embodiments of the invention and also the technical background, and in which:

Figure 1 diagrammatically shows a view of an embodiment of the invention.

Figure 2 shows a simplified flow chart of a method according to one embodiment of the invention.

Figure 3 shows the invention applied on a computer arrangement.

DESCRIPTION OF THE INVENTION

Figure 1 discloses one embodiment of the invention where a hybrid electric vehicle powertrain 1 comprises a combustion engine 2 drivingly connected to driven

wheels 3 via a master clutch 4. A permanent magnetized electric motor 5 is arranged downstream of said master clutch 4 for vehicle propulsion. Said electric motor 5 has a capacity of producing an output voltage above a human hazardous voltage limit when driven, for example, by said combustion engine and working as a generator. The electric motor 5 is further connected to an energy storage device 6. Said energy storage device can for example be an electric battery or a super capacitor, which can be charged or discharged and transmit electric power to and fro the electric motor 5. In the shown embodiment said electric motor 5 is further drivingly connected to a transmission 7, for example a step geared automatic transmission. The transmission 7 is connected with said driven wheels via a propeller shaft 8. Said master clutch 4 is an automated clutch according to known art. At least one control unit 9 can be arranged for controlling said combustion engine 2, master clutch 4, electric motor 5, energy storage device 6 and transmission 7.

According to one embodiment of the invention disclosed in figure 2 said control unit 9 is arranged to automatically upon detection of system failure 21 to disconnect 22 said energy storage device 6. A system failure indication can, for example, come from that a cable connector is loose, a component hatch is open or that there is an isolation resistance problem. Such a system failure can be detected by a detection mechanism (HVIL = Hazardous Voltage Interlock Loop) according to known art. After disconnection of said energy storage device said control unit 9 is arranged to control 23 said powertrain in such a way as to limit rotational speed of said permanent magnetized electric motor to a rotational speed limit corresponding to an output voltage from said permanent magnetized electric motor below a human hazardous voltage limit. The advantage is that the vehicle can be moved with system failure and with maintained electric security.

In an alternative embodiment of the invention said control unit 9 is in step 23 arranged to control engagement of said master clutch 4 in order to achieve said limit of rotational speed of said permanent magnetized electric motor. Thus, the combustion engine 2 runs at idle speed or as low speed as possible and engagement of the master clutch 4 is controlled in such a way as to only allow a predetermined maximum rotational speed of said electric motor 5. The control of the master clutch 4 as such can be performed according to known art. The programmed control loop can be designed to allow the needed amount of clutch slip in order to limit rotational speed of the electric motor 5 to a maximum rotational speed that corresponds to said human hazardous voltage limit.

In another embodiment of the invention said control unit is in step 23 arranged to lower idle speed of said combustion engine 2 to a lowest possible idle speed in order to limit rotational speed of the electric motor 5 to a maximum rotational speed that corresponds to said human hazardous voltage limit. If this embodiment of the invention is applicable to a certain powertrain then wear of said master clutch will be minimized.

In a further embodiment of the invention said control unit is in step 23 arranged to control both engagement of said master clutch and is also arranged to lower idle speed of said combustion engine in order to achieve said limit of rotational speed of said permanent magnetized electric motor. Said control unit can be arranged in the first place to lower said idle speed of said combustion engine and additionally in the second place when needed to perform said control engagement of said master clutch with said clutch slip. In this way overheating of said master clutch 4 can be at least postponed and the possibility to move the vehicle a certain distance can be extended.

When the system failure has been taken care of said control unit 9 can be programmed to register this and upon detection allow normal rotational speed of said hybrid electric powertrain. An alternative embodiment can be that service personnel resumes the system after the system failure has been taken care of.

Figure 3 shows an apparatus 500 according to one embodiment of the invention, comprising a nonvolatile memory 520, a processor 510 and a read and write memory 560. The memory 520 has a first memory part 530, in which a computer program for controlling the apparatus 500 is stored. The computer program in the memory part 530 for controlling the apparatus 500 can be an operating system.

The apparatus 500 can be enclosed in, for example, a control unit, such as the control unit 9. The data-processing unit 510 can comprise, for example, a microcomputer.

The memory 520 also has a second memory part 540, in which a program for controlling the powertrain function according to the invention is stored. In an alternative embodiment, the program for controlling the powertrain function is stored in a separate nonvolatile data storage medium 550, such as, for example, a CD or an exchangeable semiconductor memory. The program can be stored in an executable form or in a compressed state.

When it is stated below that the data-processing unit 510 runs a specific function, it should be clear that the data-processing unit 510 is running a specific part of the program stored in the memory 540 or a specific part of the program stored in the nonvolatile recording medium 550.

The data-processing unit 510 is tailored for communication with the memory 550 through a data bus 514. The data-processing unit 510 is also tailored for communication with the memory 520 through a data bus 512. In addition, the data-processing unit 510 is tailored for communication with the memory 560 through a data bus 511. The data-processing unit 510 is also tailored for communication with a data port 590 by the use of a data bus 515.

The method according to the present invention can be executed by the data-processing unit 510, by the data-processing unit 510 running the program stored in the memory 540 or the program stored in the nonvolatile recording medium 550.

The invention should not be deemed to be limited to the embodiments described above, but rather a number of further variants and modifications are conceivable within the scope of the following patent claims.

PATENT CLAIMS

1. Method for automatically decreasing risk of electric shock from a hybrid electric vehicle power train (1) in case of system failure, said method comprising the steps of:

a. Detecting (21) system failure in said hybrid electric vehicle power train;
b. Disconnecting (22) an energy storage device (6) arranged for providing energy to a permanent magnetized electric motor (5) of said hybrid electric vehicle power train;
c. Controlling said hybrid electric vehicle power train in such a way as to limit rotational speed of said permanent magnetized electric motor to a rotational speed limit corresponding to an output voltage from said permanent magnetized electric motor below a human hazardous voltage limit.

2. Method as in the preceding claim, characterized in that said step c comprising control of engagement of a master clutch (4) of said powertrain with a clutch slip in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

3. Method as in claim 1, characterized in that said step c comprising lowering of idle speed of a combustion engine (2) of said powertrain in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

4. Method as in said two preceding claims, characterized in that said step c comprising both control of said engagement of said master

clutch and said lowering of said idle speed in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

5. Method as in the preceding claim, characterized in that said step c comprising controlling in the first place lowering of said idle speed and additionally in the second place when needed performing control of said engagement of said master clutch.

6. Method as in the preceding claims, characterized in that said human hazardous voltage limit is 60V.

7. A hybrid electric vehicle powertrain (1) comprising a combustion engine (2) drivingly connected to driven wheels (3) via a master clutch (4), a permanent magnetized electric motor (5) arranged downstream of said master clutch for vehicle propulsion and having a capacity of producing an output voltage above a human hazardous voltage limit when driven by said combustion engine and working as a generator, where said electric motor further is connected to an energy storage device (6), a control unit (9) is arranged for controlling said powertrain, said control unit is arranged to automatically upon detection of system failure to disconnect said energy storage device, characterized in that said control unit is further arranged to control said powertrain in such a way as to limit rotational speed of said permanent magnetized electric motor to a rotational speed limit corresponding to an output voltage from said permanent magnetized electric motor below a human hazardous voltage limit.

8. A hybrid electric vehicle powertrain as in the preceding claim, characterized in that said control unit is arranged to control engagement of said master clutch with a clutch slip in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

9. A hybrid electric vehicle powertrain as in claim 7, characterized in that said control unit is arranged to lower idle speed of said combustion engine in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

10. A hybrid electric vehicle powertrain as in the two preceding claims, characterized in that said control unit is arranged to control both engagement of said master clutch and is arranged to lower idle speed of said combustion engine in order to achieve said limit of rotational speed of said permanent magnetized electric motor.

11. A hybrid electric vehicle powertrain as in the preceding claim, characterized in that said control unit is arranged in the first place to lower said idle speed of said combustion engine and additionally in the second place when needed to perform said control engagement of said master clutch with said predetermined amount of clutch slip.

12. A hybrid electric vehicle powertrain as in one of claims 7 to 11, characterized in that said human hazardous voltage limit is 60V.

13. A computer program comprising program code means for performing all the steps of any one of the claims 1 to 6 when said program is run on a computer.

14. A computer program product comprising program code means stored on a computer readable medium for performing all steps of anyone of the claims 1 to 6 when said program product is run on a computer.

15. A storage medium, such as a computer memory (520) or a nonvolatile data storage medium (550), for use in a computing environment, the memory comprising a computer readable program code to perform the method of claims 1 to 6.

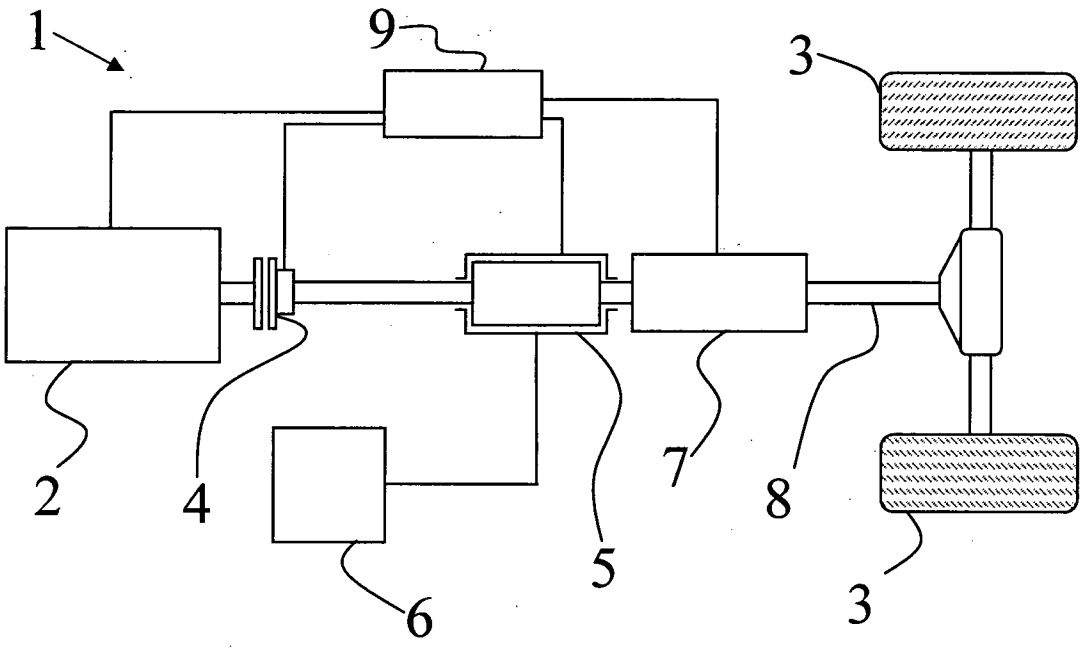

Fig. 1

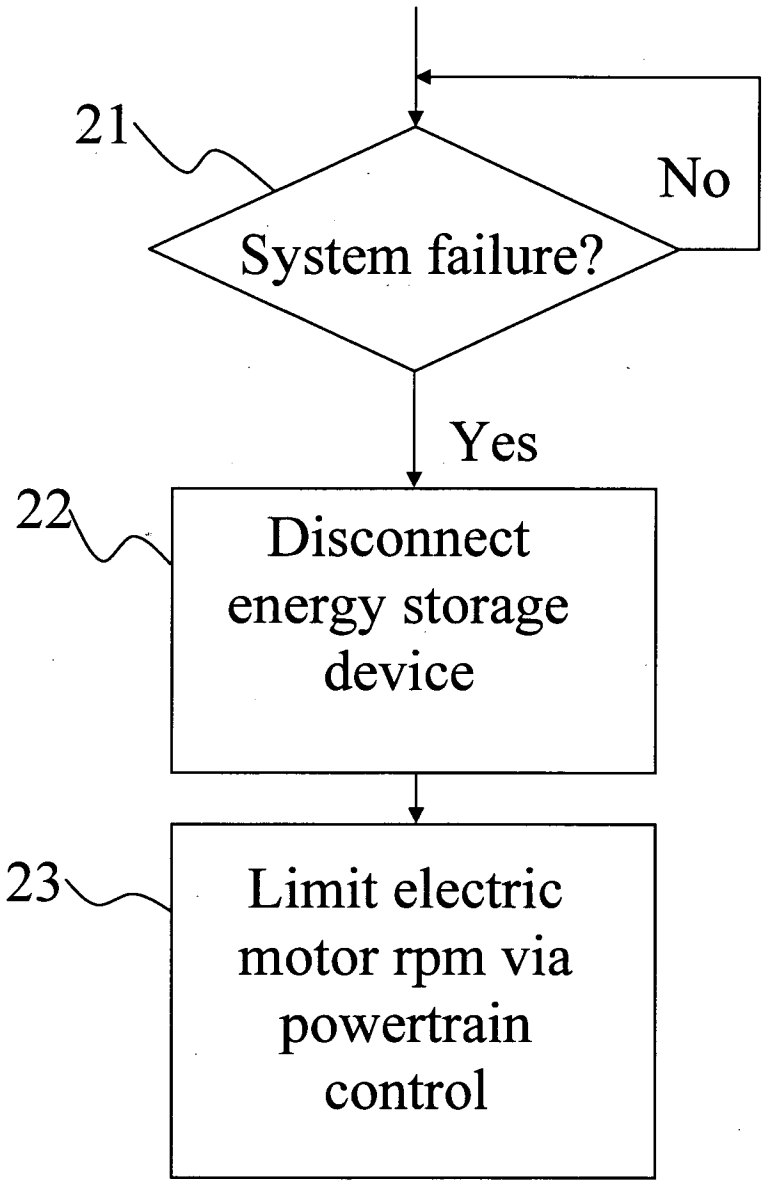
21
System failure?
No
Yes
22
Disconnect energy storage device
23
Limit electric motor rpm via powertrain control

Fig. 2

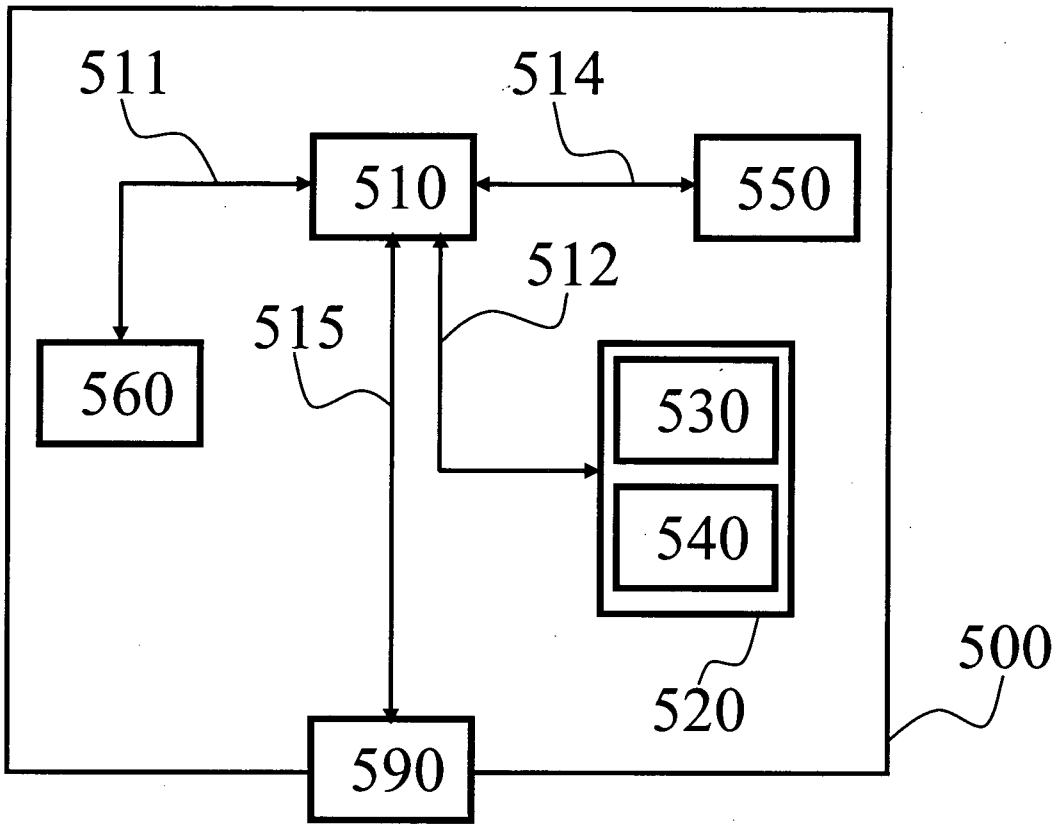

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/000624

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: H02H, 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 data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20020011935 A1 (Y.-R. KIM), 31 January 2002 (31.01.2002), figure 1, claim 1, abstract -- EP 1177931 A2 (TOYOTA JIDOSHA KABUSHIKI KA/SHA), 6 February 2002 (06.02.2002), whole document -- --------	1-15 1-15

☐ 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	Date of mailing of the international search report
28 July 2009	29 -07- 2009
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson / MRo Telephone No. +46 8 782 25 00

International patent classification (IPC)

H02H 7/09 (2006.01)
B60W 20/00 (2006.01)
H02H 3/20 (2006.01)
H02H 7/085 (2006.01)

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Cited literature, if any, will be enclosed in paper form.

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