

Radio frequency-based automatic drive switching of hybrid vehicle

5 TECHNICAL FIELD

[001] This invention relates to hybrid vehicles having dual mode of drives, e.g. an emission-less battery-powered motor and petroleum combustion engine, whereby drive mode switching needs to be performed when entering an area
10 where a particular drive mode is preferred or required. While the drive mode switching has to be performed hitherto manually by the driver or operator of the vehicle, our present invention discloses a method and apparatus for performing such switching automatically.

15

BACKGROUND ART

[002] One of the advantages of a hybrid vehicle is the ability to choose a drive mode or propulsion from two or more energy source. For example, for a
20 hybrid vehicle having an emission-less battery-powered motor as a first mode of drive and petroleum combustion engine as a second mode of drive, the first mode may be chosen when the vehicle is driven into an enclosed space or indoors in a building such as a warehouse, a hanger, cargo terminal, cold-storage rooms, etc. where exhaust emission, oxygen depletion, internal
25 combustion process and high heat generation is not desirable due to the

enclosed space and/or air conditioning.

[003] Such vehicles are usually deployed to operate both indoors and outdoors, and in the latter situation, the internal combustion engine drive mode may be switched on and the battery-powered drive may be switched off. As battery power conventionally does not last long, recharging often is required particularly when it is used to run relatively heavy machinery such as a vehicle for some time in a zero-emission area. Hence when the vehicle is driven outdoors in the combustion engine drive mode, some of this second mode of drive may also be spared to recharge the batteries for the next trip into the enclosed area.

[004] To illustrate a daily problem in a baggage handling cargo terminal of an airport where the terminal building may be air conditioned and requires zero emission control over machinery operating within the building, hybrid electric-diesel towing tractors are used. Upon entering the terminal building, the driver of the tractor are reminded to switch off the combustion engine and switch on the battery power by notice boards placed at or as gantries over the building entrance. This manual reminder method distracts the driver from concentrating on his driving and stopping at pickup and unload halt points.

[005] Often, the switchover may be forgotten and a tractor may enter a building with the petroleum combustion engine on, resulting in exhaust fumes indoors which may be slow to be dissipated by the building ventilation. On the

other hand, forgetting to switch off the battery power and switch on the combustion engine will result in the battery pack being drained and not recharged adequately for the next trip indoors. Such simple slips of memory by the drivers may thus hamper daily operation of the warehouse or luggage transporting and sorting of the terminal. It would thus be ideal if a mechanism is provided to perform the switching of drive modes of the hybrid vehicles as they enter or leaves the terminal or warehouse as a pre-designated area so that the drivers may concentrate on their driving and pickups and unloading itinerary without human errors that might result in the operation of the vehicles being interrupted or in downtime while awaiting for recharge.

[006] There are in the prior art such as U.S. Patent No. **5,072,703** which teaches temperature-based control of starting, running and stopping a second internal combustion engine for running a heavy vehicle's air conditioning, U.S. Patent No. **6,952,156** which discloses a radio-frequency transponder detection for controlling access to a vehicle's ignition, or U.S. Patent No. **7,151,464** which describes a device for controlling an electric motor by radio frequency; but none have been encountered in our search that automatically switches between 2 drive modes of a hybrid vehicle. In fact, the closest art that we could find is U.S. Patent No. **6,823,954** which provides for over-torque to smooth over the loss of drive or clutch engagement shock during manual switchover from electric motor drive to internal combustion drive. Therefore, it should be noted that this last art is cited herein not as an admission of relevant prior art but as an enabling or complementary technology to our invention.

STATEMENT OF DISCLOSURE

[007] It is thus ideal if a method or device could be provided to enable automatic switching between the drive modes of a hybrid vehicle as it is being
5 driven by an operator as it approaches or enters an area which requires a particular mode of drive to be employed instead of the other, and automatically reverts to said other mode as the vehicle is driven to exit or leave the area. In such an ideal arrangement, the driver will be able to concentrate on his driving and his route.

10

[008] In a general embodiment, our invention provides for a method for automatically switching drive modes of a hybrid vehicle, including a hybrid electric-petroleum vehicle, relative to a pre-designated area wherein said vehicle is desired to be driven in a first drive mode within said area and in a
15 second drive mode outside said area, said method comprising deploying electromagnetic means to define at least a gateway to said area; and providing on-board said vehicle means to detect said electromagnetic means, upon which the drive mode of said vehicle is switched from one drive mode to the other. Preferably, the electromagnetic means is deployed to define each of the
20 gateways, including entrance to and/or exits from said area. Preferably still, the electromagnetic means define a perimeter around said area.

[009] In a first aspect of our method, the electronic means is provided as a transponder wherein a plurality of the transponders may be deployed to define

each of said gateways, including entrances, exits and perimeter.

[010] As a second aspect, the means to detect the electromagnetic means on board said hybrid vehicle may include a transceiver capable of detecting
5 proximity of said electromagnetic means and actuating drive switching to select the drive mode accordingly.

[011] In one embodiment of our method, the automatic switching of drive modes of a hybrid vehicle may be provided with at least a radio frequency (RF)
10 transmitter which field of transmission covering at least a gateway to said area and providing on-board said vehicle at least a receiver capable of receiving the transmitted RF, upon which the drive mode of said vehicle is switched from one drive mode to the other. The first drive mode is desirably to be driven within said pre-designated area is non-emissive, including battery-powered
15 drive while the second drive mode is a combustion powered drive to be driven outside said pre-designated area.

[012] In another embodiment, a plurality of RF transmitters may be placed in and about said pre-designated area providing an RF field covering the area.
20 Alternatively, a plurality of RF transmitters may be placed around said pre-designated area defining a perimeter thereof. A single frequency or frequency range may be employed to signal to the receiver to switch on and off alternately upon each occurrence of detection. Preferably, 2 frequencies or frequency ranges are employed to signal to the receiver to switch on and to

switch off respectively. Alternatively, the switching to operate a first drive mode is maintained as long as the receiver detects the RF, and in the absence of such RF being detected, a second drive mode is switched on.

5 [013] In a preferred embodiment, the switching is preset to operate with a time lag to achieve a switching a buffer distance of about 5 m away from the pre-designated area. Preferably still, the RF emitted is at small or low frequency. Our method may be embodied in a hybrid vehicle for use in between open area and closed area including baggage tow vehicle, mobile
10 conveyor, support and supply vehicles, fork lift, cargo handling vehicles and the like. Our method may also be incorporated in a system wherein the electromagnetic means, transponder, transmitter or receiver, or combination thereof may be implemented in a method for automatically switching hybrid vehicle drives in warehouse, cargo terminal and like environment.

15

LIST OF ACCOMPANYING DRAWINGS

[014] For a better understanding of our invention, we would now refer to the
20 following drawing(s) which accompanies this specification. The drawings will be further described in detail in the following as non-limiting and exemplary illustration of specific or preferred embodiments of our invention, in which:

[015] FIGURE 1 illustrates schematically an area, such as terminal or warehouse building, which requires a specific mode of drive of a hybrid vehicle being covered or defined by overlapping fields of radio frequency transmissions according to one embodiment of our invention;

5

[016] FIGURE 2 shows a schematic diagram of a drive transmission for a hybrid vehicle with a control system according to another embodiment of our invention;

10 [017] FIGURE 3 depicts a schematic diagram of RF control circuit on board a hybrid vehicle according to another embodiment of our invention; and

[018] FIGURE 4 illustrates an algorithm of the automatic switching between the two operating modes of drive according to our invention.

15

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[019] In broad, general terms of our invention concerns a method for
20 automatically switching drive modes of a hybrid vehicle which may be defined as including a hybrid electric-petroleum vehicle. Generally, the switching is actuated relative to a pre-designated area wherein it is desirable for the vehicle to be driven in a first drive mode within the area and in a second drive mode outside said area. Specifically, the first mode is a non-emissive or emission-

free non oxygen depleting, non high heat generating drive such as battery-powered motor operation while the second drive mode is an internal combustion engine. Our method includes, in principle, deploying electromagnetic means to define at least a gateway to the pre-designated area
5 and further providing, on-board the hybrid vehicle, means to detect the electromagnetic means. Upon the detection of the electromagnetic means, the drive mode of the vehicle is switched from one drive mode to the other.

[020] It is to be understood in this specification that –

10 “petroleum”, or “combustion” engine include conventional internal combustion engines running on diesel, petrol or other forms of fossil fuels/organic fuel/bio-fuel;

“electromagnetic means” include any signal or field of the electromagnetic spectrum including radio waves or radio frequency or Infra-red
15 or laser or ultrasonic or location based sensors (GPS) or visual identification, and any active or passive electronic device operative with such signal or field, including transponder, transmitter, receiver, camera and the like.

“Gateway” will also be understood as entrance or exits of (or used for entering and exiting) a zero-emission control area, which in the following an air-
20 conditioned warehouse will be used as an example of such emission controlled area.

[021] There are many possible configurations or embodiments to our invention, particularly, in respect of the deployment of the electromagnetic

means. For instance, the electromagnetic means may be deployed only at the entrances to or exits from the area in which zero emission policy is to be enforced, or multiple units of the electromagnetic means may be deployed so as to define a perimeter around the area.

5

[022] As defined above, the electromagnetic means may be an active or passive device such as a transponder placed at the gateway to the warehouse whereby the hybrid vehicle may pass as it enters or exits the warehouse. As with passive transponders, such as embodied in the popular radio frequency identification (RFID) tags, no power supply is required to work the transponder placed at the gateway. As with RFID or passive transponder, it may derive power from radio waves coming into contact with it and generate a signal to be read by a receiver. As such, a suitable RF transceiver may be installed at a position on board the hybrid vehicle that could easily transmit RF to and receive signal from the transponder. The signal received from the transponder could then be programmed to actuate an electronic circuit on the hybrid vehicle that could perform the switching of drive modes, e.g. switching off the ignition to the combustion engine and switching on the battery-powered motor to continue driving the vehicle.

20

[023] With the use of such transponders to define or mark the gateways or perimeter of the warehouse or zero-emission control area, gateways may be quickly set up or changed as a situation warrants. Many of the features of our invention may be incorporated into hybrid marine vehicles in addition to land-

based vehicles. E.g. ecological tours in open vegetation or wildlife areas where exhaust fumes and excessive combustion engine noise would drive away insects or animals to be observed, or react to volatile fluids, such transponder gateways may be quickly set up or repositioned according to terrain, tide, migration of creatures or drift of oil slick, etc., so that the hybrid vehicle or boat enters the controlled area with the least hazardous mode of drive.

[024] Apart from transponders and the use of transceivers aboard the hybrid vehicles, the method of our invention may also be implement by providing at least a radio frequency (RF) transmitter which field of transmission covering at least a gateway to controlled area, such as the example of a warehouse, and also providing on-board the hybrid vehicle at least a receiver capable of receiving the transmitted RF. Upon the receiving or detection of the RF signal the drive mode of said vehicle may be switched from one drive mode to the other by electronic logic means.

[025] As with the transponders, the transmitters may be arranged in a layout and in sufficient numbers to cover each of the gateways to the warehouse, or form a complete perimeter around the warehouse, or as shown in **FIGURE 1**, to completely cover the floor area of the warehouse with a perimeter space as buffer.

[026] **FIGURE 2** shows a schematic diagram of a hybrid vehicle having a drive transmission which may be controlled with an auto-switching control

system according to our present invention. Key to the RF control system is the RF Receiver Board 22 which components and circuit board may be installed at a suitable location for ease of receiving RF depending on the transmitter's location and height with respect to the vehicle's passing by the transmitter, i.e. whether on the left or right side, window or bumper height, etc., which is also dependent on the strength or distance of effective transmission of the radio wave.

[027] Upon receiving the RF signal, a logic device on board the RF Receiver Board 22 may activate or deactivate the combustion engine 24, as the case may be. If the engine 24 is activated, the battery power supply 26 will be deactivated and vice versa. If the engine is activated, the normal combustion drive transmission to the differential axle may occur and the driver may drive the vehicle as normal. A preferred embodiment of the drive transmission would be that shown in FIG. 2 wherein a generator 28 is shown coupled permanently to the engine wherein during combustion drive it is also used to run the generator 28 to recharge the battery 26 which may be regulated by a generator controller 30. If the engine 24 is deactivated, the generator controller 30 may sense that the engine 24 is NOT running and will hence NOT charge the battery 26 but would instead, via a separate motor controller 32, enable the battery 26 to discharge to run a motor 34 to drive the vehicle's differential axle 36.

[028] In **FIGURE 3**, a schematic diagram of RF control circuit on board a

hybrid vehicle is shown whereby the actuating signals may be transmitted via general input/output (GIO) ports A and B and which are shown connected via opto-couplers to protect the sensitive RF circuit from the excessive current or voltage of the components to be actuated. With this break in the electrical contact between the RF receiver board and the other components of the hybrid vehicle such as the high power relay and starter relay for the engine's starter connected to the GIO-A port and the fuel solenoid for starving off fuel to the engine which circuit is connected to GIO-B port of the RF Receiver Board, the RF receiving components are protected. It should be noted that this example of

5

FIGURE 3 only shows the circuitry schematics for a diesel engine of the hybrid vehicle. For a hybrid vehicle which combustion drive employs a petrol engine, instead of the fuel solenoid, connection to the ignition system may be provided.

10

[029] As shown in **FIGURE 4**, wherein an algorithm of the automatic switching between the two operating modes of drive is illustrated, the signals from the transmitters that are received by the RF Receiver Board are transmitted via the GIO-A and GIO-B ports according to digital logic whereby time lag (shown in **FIGURE 4** is 3 seconds) may be set so that the vehicle moves clear of the warehouse perimeter before the diesel engine is started and the battery power switched off to switch the drive mode to combustion mode.

15

20

The preferred buffer distance is about 5 metres from the warehouse gateway and the time lag of 3 seconds may be varied according to the vehicle's average speed to achieve the desired buffer distance.

[030] It is also apparent to a skilled person that apart from employing a single RF signal or frequency transmission so that the switching is performed in toggle or alternating mode (i.e. first instance of detecting the RF signal switches the combustion mode to battery mode, next detection reverts to combustion mode and so forth), it is also possible to configure the transceiving set up to deal with 2 different RF signals or frequencies, i.e. one signal to specifically switch from combustion to battery mode and a second signal to specifically switch from battery mode to combustion mode.

[031] Another preferred feature is to install multiple transmitters that provide lower power transmissions as compared to a single transmitters with a higher power transmission so as to reduce health risks to the driver and personnel working in and around the warehouse.

[032] In addition to hybrid vehicles shuttling between indoors of a warehouse and outdoors, our invention may also be implemented for a wide range of hybrid vehicles to be driven alternating between open area and closed area including airport baggage tow vehicle, mobile conveyor, hospital buses, eco-friendly theme park buses, Inter-City Center Buses, support and supply vehicles, fork lift, cargo handling vehicles and the like. It is also useful for setting a temporary or arbitrary perimeter or transient gateway to a protected wildlife, hazmat, disaster or hostility zone where exhaust gas or noise cannot be tolerated.

[033] It will also be apparent to a skilled person to modify and adapt our invention to a wide range of configurations. For instance, with passive transponder devices marking the gateways, a temporary gateway may be set up at any time or at any point by having the transponder devices affixed at
5 removable pole stands marking the gateway. For a longer range buffer switching zone, i.e. to enable a longer range of RF to be detected, active transponder may be used instead. If more signal inputs are to be processed apart from the detection of the ON or OFF RF signals to decide if the vehicle's drive switching should be activated, more complicated logic flow or artificial
10 intelligence technology may be employed.

[034] If a structured signal is required to avoid or filter interferences, electronic noise or conflicts with other forms of RF prevalent at the operation site, our RF transmission may be arranged to be transmitted in data packets or
15 protocols which may be incorporated into our algorithm with provision for compensation for possible lost of transmitted data packets which is inherent in RF. These variations and other modifications are to be considered as falling within the scope and letter of the following claims.

CLAIMS

What we claim are:

- 5 1. A method for automatically switching drive modes of a hybrid vehicle, including a hybrid electric-petroleum vehicle, relative to a pre-designated area wherein said vehicle is desired to be driven in a first drive mode within said area and in a second drive mode outside said area, said method comprising:
 - (i) 10 deploying electromagnetic means to define at least a gateway to said area;
 - (ii) providing on-board said vehicle means to detect said electromagnetic means, upon which the drive mode of said vehicle is switched from one drive mode to the other.
- 15 2. A method for automatically switching drive modes of a hybrid vehicle according to Claim 1 wherein the electromagnetic means is deployed to define each of said gateways, including entrance to and/or exits from said area.
3. A method for automatically switching drive modes of a hybrid vehicle
20 according to Claim 1 wherein the electromagnetic means define a perimeter around said area.
4. A method for automatically switching drive modes of a hybrid vehicle according to Claim 1 wherein the electronic means is at least a transponder.

5. A method for automatically switching drive modes of a hybrid vehicle according to Claim 4 wherein a plurality of transponders are deployed to define each of said gateway, including entrances, exits and perimeter.

5

6. A method for automatically switching drive modes of a hybrid vehicle according to Claim 1 wherein the means to detect the electromagnetic means on board said hybrid vehicle include a transceiver capable of detecting proximity of said electromagnetic means and actuating drive switching to select
10 the drive mode accordingly.

7. A method for automatically switching drive modes of a hybrid vehicle according to Claim 1 comprising:

- (i) providing at least a radio frequency (RF) transmitter which field of
15 transmission covering at least a gateway to said area;
- (ii) providing on-board said vehicle at least a receiver capable of receiving the transmitted RF, upon which the drive mode of said vehicle is switched from one drive mode to the other.

20 8. A method for automatically switching drive modes of a hybrid vehicle according to Claim 7 wherein the first drive mode desirable to be driven within said pre-designated area is non-emissive, including battery-powered drive; and wherein the second drive mode is a combustion powered drive to be driven outside said pre-designated area.

9. A method for automatically switching drive modes of a hybrid vehicle according to Claim 7 wherein a plurality of RF transmitters are placed in and about said pre-designated area providing an RF field covering said area.

5

10. A method for automatically switching drive modes of a hybrid vehicle according to Claim 7 wherein a plurality of RF transmitters are placed around said pre-designated area defining a perimeter thereof.

10 11. A method for automatically switching drive modes of a hybrid vehicle according to Claim 7 wherein a single frequency or frequency range is employed to signal to the receiver to switch on and off alternately upon each occurrence of detection.

15 12. A method for automatically switching drive modes of a hybrid vehicle according to Claim 7 wherein 2 frequencies or frequency ranges are employed to signal to the receiver to switch on and to switch off respectively.

13. A method for automatically switching drive modes of a hybrid vehicle
20 according to Claim 9 wherein the switching to operate a first drive mode is maintained as long as the receiver detects the RF, and in the absence of such RF being detected, a second drive mode is switched on.

14. A method for automatically switching drive modes of a hybrid vehicle

according to any one of Claims 7 – 13 wherein the switching is preset to operate with a time lag to achieve a switching a buffer distance of about 5 m away from the pre-designated area.

5 15. A method for automatically switching drive modes of a hybrid vehicle according to any one of Claims 7 – 13 wherein the RF emitted is at a low power transmission.

16. An apparatus implementing a method according to any one of Claims 1
10 – 15 embodied in a hybrid vehicle for use in between open area and closed area including baggage tow vehicle, mobile conveyor, support and supply vehicles, fork lift, cargo handling vehicles and the like.

17. A system incorporating at least an electromagnetic means, transponder,
15 transmitter or receiver, or combination thereof employed in a method and/or an apparatus according to any one of the preceding claims implemented in warehouse, cargo terminal and like environment.