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(54) Title: AUTOMATIC ENGINE START CHECK FOR HYBRID VEHICLES

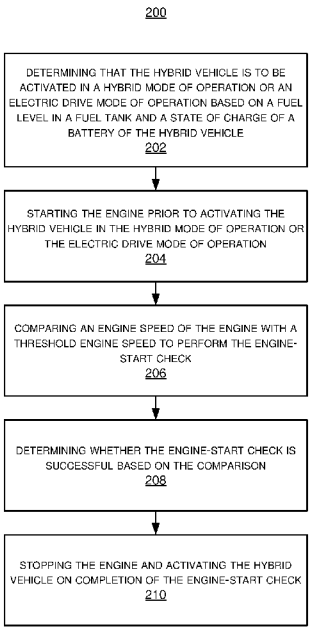

Fig. 2

(57) Abstract: Performance of an engine-start check for a hybrid vehicle (106) comprising an engine (108) and a battery operated motive power source (114) is discussed. It is determined that the hybrid vehicle (106) is to be activated in a hybrid mode of operation or an electric drive mode of operation based on a fuel level in a fuel tank (110) and a state of charge of a battery (112) of the hybrid vehicle (106). The engine (108) is started prior to activating the hybrid vehicle (106) in the hybrid mode of operation or the electric drive mode of operation. An engine speed of the engine (108) is compared with a threshold engine speed to perform the engine-start check. It is determined whether the engine-start check is successful based on the comparison. The engine (108) is stopped, and the hybrid vehicle (106) is activated on completion of the engine-start check.

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TECHNICAL FIELD

[0001] The subject matter described herein relates to methods and systems for performing automatic engine-start check, particularly for hybrid vehicles.

BACKGROUND

[0002] Conventionally, vehicles, such as motorbikes and cars, are operated using an Internal Combustion (IC) engine or an electrical propulsion mechanism, such as an electric motor. The vehicles that use IC engine add to emissions in the form of smoke that get added to the atmosphere, while the vehicles that use electrical propulsion do not emit smoke. On the other hand, the vehicles that use electrical propulsion have less power compared to the vehicles that use IC engine. Vehicle manufacturers have started combining both IC engine and electrical propulsion together to get the advantage of both in the vehicles in vehicles called hybrid vehicles. In hybrid vehicles, a drive mode could be IC engine alone, electric motor alone, or a combination of both.

BRIEF DESCRIPTION OF DRAWINGS

[0003] The detailed description is described with reference to the accompanying figures. In the figures, the left most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the drawings to reference like features and components.

[0004] Fig. 1 illustrates a block diagram of a system for performing engine-start check of a hybrid vehicle, in accordance with an example implementation of the present subject matter.

[0005] Fig. 2 illustrates a method of performing engine-start check, in accordance with an example implementation of the present subject matter.

[0006] Figs. 3a and 3b illustrate methods to determine a mode of operation of a hybrid vehicle based on a level of fuel and a state of charge of a battery of the vehicle, in accordance with an example implementation of the present subject matter.

[0007] Fig. 4 illustrates a method for performing engine-start check in hybrid or electric drive mode of operation, in accordance with an example implementation of the present subject matter.

[0008] Fig. 5 illustrates a dashboard of a hybrid vehicle, in accordance with an example implementation of the present subject matter.

DETAILED DESCRIPTION

[0009] The present subject matter described herein relates to methods and systems for performing engine-start check for hybrid vehicles. Hybrid vehicles include an internal combustion (IC) engine, also referred to as engine, and a battery operated motive power source or electric propulsion mechanism, such as an electric motor.

[0010] In conventional hybrid vehicles, at times, the internal combustion engine may have to be started automatically while the vehicle is being operated on an electric motor, also referred to as an electric drive mode of operation. For example, when the hybrid vehicle lacks sufficient acceleration while overtaking, climbing a gradient or the like, while being operated on an electric drive mode alone, the IC engine has to be started automatically to assist the electric motor. Failure to start the IC engine in such situations may become a safety concern. The failure may occur for various reasons, such as low engine oil temperature, low engine temperature, failure of starter motor, etc.

[0011] The present subject matter discloses automatic engine-start check systems and methods for hybrid vehicles. In an example implementation of the present subject matter, an engine of a hybrid vehicle, also referred to as a vehicle can be started on demand. In an example, vehicle parameters such as fuel level and battery state of charge are obtained to determine a mode of operation in which the vehicle is to be activated. If the vehicle mode of operation is determined to be hybrid mode or electric drive mode, the engine is started to check if the engine is operational, prior to activating the vehicle. If the start check is unsuccessful, the rider may be made aware prior to activating the vehicle. The indication of the failure alerts the rider of the vehicle, so that the rider may ride the vehicle in electric drive mode of operation and get necessary support at the earliest.

[0012] The hybrid vehicle in which the present subject matter may be implemented may be any hybrid vehicle, such as a two-wheeled vehicle, a three wheeled vehicle, a four wheeled vehicle, etc.

[0013] The above and other features, aspects, and advantages of the subject matter will be better explained with regard to the following description and accompanying figures. It should be noted that the description and figures merely illustrate the principles of the present subject matter along with examples described herein and, should not be construed as a limitation to the present subject matter. It is thus understood that various arrangements may be devised that, although not explicitly described or shown herein, embody the principles of the present disclosure. Moreover, all statements herein reciting principles, aspects, and examples thereof, are intended to encompass equivalents thereof. Further, for the sake of simplicity, and without limitation, the same numbers are used throughout the drawings to reference like features and components.

[0014] Fig. 1 illustrates a block diagram of a system 100 for automatic engine-start check operation of a hybrid vehicle, in accordance with an implementation of the present subject matter. The system 100 can include a controller 102 and an ignition control unit 104. In one example, the controller 102 may be an Electronic Control Unit (ECU) of a hybrid vehicle 106, also referred to as vehicle 106, and may be implemented as any microcontroller or processing unit as may be understood by a person skilled in the art. The ignition control unit 104 may be a transistor controlled ignition (TCI) unit or any other suitable ignition control unit. The ignition control unit 104 may include various components, such as an ignition coil, a processor, relays, a memory storing ignition maps, etc., which will be understood and are not described for brevity. As may be appreciated, the ignition control unit 104 may control the ignition timing for ignition provided to an engine 108 of the hybrid vehicle 106. The hybrid vehicle 106 may be any hybrid vehicle with any number of wheels. Accordingly, the hybrid vehicle 106 may be operated by a rider or driver and the term rider is intended to include driver as well.

[0015] The hybrid vehicle 106 may include the engine 108, a fuel tank 110 to supply fuel to the engine 108, a battery 112, an electric motor 114, a dashboard 116,

switches 118, sensors 120, and various other components for its functioning as may be appreciated by a person skilled in the art. The switches 118 may include an ignition switch, a brake switch, and an activation switch amongst other switches. The sensors 120 may include a fuel level sensor, an engine oil temperature sensor, a throttle position sensor, and an engine speed sensor, amongst other sensors. Additionally, the vehicle 106 may include a battery management system (BMS) associated with the battery 112 that may monitor and provide the battery state of charge to the controller 102. The controller 102 may be communicatively coupled to the ignition control unit 104 and various other components via, for example, controller area network (CAN) lines. In one example, the controller 102 may receive status of the various switches 118 and sensors 120 over the CAN lines.

[0016] In operation, the controller 102 may determine that the hybrid vehicle 106 is to be activated in a hybrid mode of operation or an electric drive mode of operation based on a fuel level in the fuel tank 110 and a state of charge of the battery 112. In one example, when an ignition switch of the vehicle 106 is switched ON, a throttle position of the hybrid vehicle 106 corresponds to idling (i.e., is at substantially zero percentage throttle), an activation switch of the hybrid vehicle 106 is switched ON, and a brake switch of the hybrid vehicle 106 is switched ON, the controller 102 may determine that a rider would like to activate the vehicle 106. Prior to activating the vehicle 106, the controller 102 may obtain the fuel level and the battery state of charge from corresponding sensors to determine a mode of operation of the vehicle 106.

[0017] Further, the controller 102 may compare the fuel level with a threshold fuel level and the battery state of charge with a threshold battery state of charge; and determine a mode of operation for activating the hybrid vehicle 106. The controller 102 may also determine an estimated running distance on determining the mode of operation and display the mode of operation and the running distance on the dashboard 116 of the hybrid vehicle 106 to make the ride aware of the operational condition of the vehicle 106 prior to its activation.

[0018] In one example, when the fuel level is less than the threshold fuel level and the battery state of charge is less than the threshold battery state of charge, the mode

of operation may be determined to be immobile or limp home mode for both the engine 108 and electric motor 114. As is understood, a limp home mode is a safety feature provided in vehicles that allows a vehicle having a fault in the motive power source or transmission system to move for some distance on minimal power so that a rider/ driver may obtain required assistance for servicing the vehicle. Accordingly, on receiving an indication that the vehicle 106 is immobile, the rider may take the vehicle 106 to a nearest charging center or petrol station or to an assistance center for receiving assistance.

[0019] In another example, when the fuel level is not less than the threshold fuel level, i.e., fuel level is greater than or equal to the threshold fuel level, and the battery state of charge is not less than the threshold battery state of charge, i.e., the battery state of charge is greater than or equal to the threshold battery state of charge, the mode of operation may be determined to be a hybrid mode. In the hybrid mode, the vehicle 106 may start in an electric drive mode by default and the engine 108 may assist the electric motor 114 in case more power is required.

[0020] In another example, when the fuel level is not less than the threshold fuel level, i.e., fuel level is greater than or equal to the threshold fuel level, and the battery state of charge is less than the threshold battery state of charge, the mode of operation may be determined to be an engine mode of operation. In the engine mode of operation, the vehicle 106 is operated primarily by the engine 108 while the electric motor 114 is to be operable in a limp home mode in case of emergency.

[0021] In another example, when the fuel level is less than the threshold fuel level and the battery state of charge is not less than the threshold battery state of charge, i.e., the battery state of charge is greater than or equal to the threshold battery state of charge, the mode of operation is determined to be the electric drive mode of operation. In the electric drive mode of operation, the vehicle 106 is operated primarily by the electric motor 114 while the engine 108 is to be operable in the limp home mode in case of emergency.

[0022] On determining the mode of operation, the controller 102 is to perform an engine-start check automatically prior to activating the determined mode of operation when the mode of operation is determined to be the hybrid mode or the

electric drive mode. Activating the determined mode of operation refers to allowing the vehicle 106 to operate in the determined mode of operation. The activating may be performed by the controller 102 by methods known in the art and hence is not described.

[0023] The engine-start check may be performed for the hybrid mode and the electric drive mode to ensure that in case the engine 108 is to later be started, while the vehicle 106 is being driven by the electric motor114 in the hybrid mode or the electric drive mode, the engine 108 is likely to start without any problems associated therewith.

[0024] In one example, to perform the engine-start check, the engine 108 may be started prior to activating the hybrid vehicle 106. For this, the controller 102 may send a signal to the ignition control unit 104 to identify an ignition map for controlling ignition timing of the engine 108. The ignition control unit 104 may identify an ignition map based on an engine oil temperature. For example, the ignition control unit 104 may select a base ignition map when the engine oil temperature is greater than a threshold temperature and may select a heating ignition map when the engine oil temperature is not greater than the threshold temperature, i.e., when the engine oil temperature is less than or equal to the threshold temperature.

[0025] Ignition maps are typically provided for selecting ignition timing (i.e., angular position of the engine crankshaft/ position of piston at which ignition is to be done), as a function of engine speed and throttle position for each mode of operation of the vehicle 106. The ignition maps may be pre-built or stored in the ignition control unit 104 by a manufacturer of the vehicle 106. In operation, the ignition control unit 104 may receive the engine speed, engine oil temperature, and the throttle position directly or from the controller 102. Additionally, the mode of operation may be sent by the controller 102 to the ignition control unit 104 for selection of an ignition map for operating the engine 108.

[0026] The base ignition map may refer to an ignition map determined for controlling ignition timing with respect to engine speed and throttle position for

operating the engine 108 for a particular mode of operation without any corrections for temperature.

[0027] The heating ignition map may refer to an ignition map determined for controlling ignition timing with respect to engine speed and throttle position for operating the engine 108 for cold start operation for a particular mode of operation. For example, based on a comparison of temperature read by a sensor mounted on a crankcase with a pre-set temperature or comparison of engine oil temperature with the threshold temperature, the ignition angle provided in the heating ignition map will be added to the angle provided in the base ignition mapping and accordingly the ignition timing and the ignition angle at which an ignition coil is fired may be determined. Thus, as may be understood, for cold start operation the ignition angle may be advanced as compared to normal or hot start operation.

[0028] It will be understood that the ignition control unit 104 may store various ignition maps to be used for different operating conditions and operating modes of the vehicle 106 as may be provided by a manufacturer of the vehicle 106 and/or may be updated during the life time of the vehicle 106.

[0029] In one example, the ignition control unit 104 may also actuate a cold start solenoid of a starter circuit, for example, of a carburetor or a fuel injector (not shown in the figure) of the hybrid vehicle 106 for cold starting the engine 108 when the engine oil temperature is not greater than the threshold temperature. Further, the controller 102 may crank the engine by a starter motor (not shown in the figure) and the ignition control unit 104 may provide ignition to the engine 108 based on the selected ignition map upon cranking of the engine.

[0030] The controller 102 may then monitor an engine speed of the engine 108 and may compare the engine speed with a threshold engine speed to perform the engine-start check and may determine whether the engine-start check is successful based on the comparison. In one example, the controller 102 may compare the engine speed with the threshold engine speed after expiry of a delay time from a time of starting the engine 108 to allow the engine speed to reach a steady value before the comparison.

[0031] In one example, the engine-start check may be indicated to be a failure when the engine speed is less than the threshold engine speed, while the engine-start check may be indicated to be a success when the engine speed is not less than the threshold engine speed, i.e., the engine speed is equal to or greater than the threshold engine speed. In one example, the success or failure of the engine-start check may be indicated through the dashboard 116 by providing one or more of an audio signal through a speaker on the dashboard, a text message on a display of the dashboard, a lighted symbol on the display, and a light indicator on the dashboard. Further, the controller 102 may stop the engine 108 and activate the hybrid vehicle 106 in the determined mode of operation on completion of the engine-start check.

[0032] Figs. 2, 3a, 3b, and 4 illustrate methods according to various example implementations of the present subject matter. The order in which the methods are described is not intended to be construed as a limitation, and some of the described method blocks can be combined in a different order to implement the methods or alternative methods. Furthermore, the methods may be implemented in any suitable hardware, computer readable instructions, or combination thereof. The blocks of the methods may be performed by either a processor/ controller under the instruction of machine executable instructions or by dedicated hardware circuits, microcontrollers, or logic circuits. While the methods may be implemented in any device, the following description is provided in the context of system 100 as described earlier with reference to Fig. 1 for ease of discussion.

[0033] Fig. 2 illustrates a method 200 of performing engine-start check in accordance with an example implementation of the present subject matter. The method 200 may be performed for a hybrid vehicle, such as vehicle 106, comprising an engine 108 and a battery operated motive power source, such as the electric motor 114, as discussed earlier with reference to Fig. 1.

[0034] At block 202, it is determined that the hybrid vehicle is to be activated in a hybrid mode of operation or an electric drive mode of operation based on a fuel level in a fuel tank and a state of charge of a battery of the hybrid vehicle. For example, the controller 102 may determine the mode of operation of the vehicle 106 based on the fuel level and the state of charge, and may then perform the

engine-start check when the mode of operation is determined to be a hybrid mode of operation or an electric drive mode of operation. The determination of mode of operation will be discussed in detail with reference to Figs. 3a and 3b.

[0035] At block 204, the engine may be started prior to activating the hybrid vehicle in the hybrid mode of operation or the electric drive mode of operation. For example, the controller 102 may crank the engine 108 using a starter motor and may operate the engine 108 using the ignition control unit 104. For this, the ignition control unit 104 may select an ignition map based on an engine oil temperature. Further, the ignition control unit 104 may actuate a cold start solenoid of the hybrid vehicle 106 for cold starting the engine 108 when the engine oil temperature is not greater than the threshold temperature

[0036] At block 206, an engine speed of the engine may be compared with a threshold engine speed to perform the engine-start check. For example, the controller 102 may compare the engine speed with the threshold speed to determine whether the engine may be started without any problems in case it is required during the hybrid mode or electric drive mode of operation. In one example, the comparison is performed after lapse of a delay time from starting the engine to allow the engine speed to stabilize after starting.

[0037] At block 208, it is determined whether the engine-start check is successful based on the comparison. For example, the controller 102 may determine the engine-start check to be successful if the engine speed reaches a speed that is greater than or equal to the threshold speed. On the other hand, the controller 102 may determine the engine-start check to be unsuccessful if the engine speed reaches a speed that is less than the threshold speed. In one example, one or more of an audio signal, a text message on a display, a colored lighted symbol on the display, and a light indicator may be used to indicate the success or failure of the engine-start check on a dashboard of the vehicle for the reference of the rider.

[0038] At block 210, the engine may be stopped and the hybrid vehicle may be activated on completion of the engine-start check to operate the hybrid vehicle in the determined mode of operation.

[0039] Figs. 3a and 3b illustrate methods 300 and 350 to determine a mode of operation of a hybrid vehicle based on a level of fuel and a state of charge of a battery of the vehicle, in accordance with an example implementation of the present subject matter.

[0040] As shown in Fig. 3a, at block 302, a controller, such as the controller 102 may receive a signal from an ignition switch to read status of the ignition switch. At block 304, the controller 102 may determine if the ignition switch is ON or not. If at block 304 the ignition switch is determined to be not switched ON, then the status of the ignition switch is further continually monitored.

[0041] When the ignition switch at block 304 is identified as switched ON, a rider of the vehicle is prompted at block 306 for activating the vehicle. Th activation of the vehicle may be done for operating the vehicle and may have to be done separately so that the vehicle does not start by accident. Thus, having an activation switch in addition to the ignition switch provides a safety mechanism for starting the vehicle. In an example, the prompt message is displayed on a display unit of the dashboard 116.

[0042] At block 308, the controller 102 may read a throttle position from a throttle position sensor, a brake switch, and an activation switch to determine the position of the throttle, status of the brake switch, and status of activation switch respectively.

[0043] At block 310, if the throttle position is in idling position or substantially zero position, the brake switch is in ON condition, and the activation switch is in ON condition, the controller 102 activates the vehicle. Else, the controller 102 may continue to provide a prompt at block 306.

[0044] At block 312, when the vehicle activated, the controller 102 may detect a level of fuel and a state of charge (SOC) of the battery. In an example, the controller 102 may read the level of fuel of a fuel tank using a fuel sensor and a state of charge of the battery using a Battery Management System (BMS). Further, at block 314, the controller 102 can calculate a distance that the vehicle can travel with the amount of fuel and electrical energy available for the plurality of drive modes, such as an engine based limp home mode, an electric drive based limp home mode,

immobile mode, and hybrid mode, of the vehicle. The controller 102 can also display the distance for all modes on a display unit, such as the dashboard 116 of the vehicle 106.

[0045] At block 316, determination is made to check if the level of fuel and state of charge of the battery are above or below their respective pre-set minimum/ threshold values. If both the level of fuel and state of charge are below their respective pre-set minimum values, the controller 102 may display an indication on the display unit of both low fuel and low battery to the rider at block 318 and the vehicle may be made immobile or operable in limp home mode. If, however, at least one of the level of fuel and the state of charge of the vehicle are above their pre-set minimum values, then at block 320, the controller 102 can further continue to determine mode of operation of the vehicle.

[0046] Referring to Fig. 3b, which continues from block 320, at block 352, a controller, such as the controller 102 may determine the state of charge (SOC) of the battery from a battery management system (BMS). Based on the determination, it is analyzed if the state of charge is above or below a pre-set minimum/ threshold SOC.

[0047] If the controller 102 determines that the SOC is below the pre-set minimum SOC, then at block 354, the controller 102 may display the amount of SOC of battery on a display unit. Additionally, the controller 102 detects the amount of fuel available in the vehicle from a fuel sensor to display a distance that the vehicle can travel operating just on the fuel till it reaches an empty fuel tank condition. Further, the controller 102 sets the mode of operation to the engine operation mode with a limp home mode for the electric drive at block 356. In this case, the engine works primarily for powering the vehicle 106, and the electric motor is not operated unless in case of an emergency. In an example, the controller 102 may also prompt the rider of the vehicle to charge the vehicle by indicating the low battery level on the display unit.

[0048] If the controller 102 establishes that the state of charge of battery is not below the pre-set minimum SOC, the controller 102 may compare the level of fuel with pre-set minimum/ threshold level of fuel at block 358.

[0049] In an example, if the controller 102 determines that the level of fuel is below the pre-set minimum level of fuel, then at block 360, the controller 102 may display the level of fuel to the rider. Further, the controller 102 can also determine and display a distance that the vehicle can travel operating just on the battery until the battery is drained and may display the distance at block 360. Further, at block 362, the controller 102 may set the mode of operation of the vehicle to an electric drive operation mode with an engine limp home mode such that electric motor works primarily for powering the vehicle 106 and the engine is not used unless in an emergency. In an example, the controller 102 can prompt the rider to refill the fuel by indicating the low fuel level on the display unit.

[0050] Further, at block 364, if the controller 102 establishes that the state of charge of battery is above or equal to the pre-set minimum SOC and the level of fuel is also above or equal to the pre-set minimum level of fuel then, the controller 102 may set the mode of operation of the vehicle to a hybrid mode. In the hybrid mode, the electric drive operation mode may be the default mode of operation with the engine mode used for additional power.

[0051] Additionally, after the blocks 362 and 364, the controller 102 may perform automatic engine-start check as will be discussed with reference to Fig. 4, to ensure that the engine may be safely started in case it is required while the vehicle is being run by power from the electric motor.

[0052] Fig. 4 illustrates a method 400 for performing engine-start check in hybrid or electric drive mode of operation, in accordance with an example implementation of the present subject matter. In an example, as has been discussed, a controller such as the controller 102 can determine that the vehicle is to be activated in a hybrid mode or electric drive mode. When the vehicle is activated in hybrid mode or engine limp home mode, to check the readiness of vehicle for engine operation, at block 402, an ignition control unit 104 such as a transistor controlled ignition (TCI) unit can estimate a temperature of engine oil of the vehicle. In an example, the temperature of the engine oil can be obtained using a temperature sensor.

[0053] The ignition control unit 104 can further compare the estimated temperature of the engine oil with a pre-set/ threshold temperature. At block 404, if the estimated

temperature is determined to be less than or equal to the pre-set temperature, then the ignition control unit actuates a solenoid at block 406 and selects a heating ignition map at block 408. The solenoid may be a usually closed solenoid which when actuated opens the starter circuit of a carburetor or fuel injector of the IC engine for cold starting. The heating ignition map, as may be understood, may be used to correct the base ignition map for cold start conditions.

[0054] If at block 404, the ignition control unit 104 determines the temperature of the engine oil to be above the pre-set temperature then, at block 410, the ignition control unit 104 selects a base ignition map, without temperature corrections, for operating the engine.

[0055] Once an ignition map is selected, at block 412, an engine-start check message is displayed on the display unit to indicate to the rider that an engine-start check is being performed. At block 414, the controller 102 may crank the engine with a starter motor and start the engine of the vehicle with operation of the ignition control unit 104. After the engine starts, a delay is allowed before determining speed of the engine as shown in block 416.

[0056] At block 418, the controller 102 can monitor the speed of the engine with a rotation per minute (rpm) sensor mounted suitably on the crankshaft of the engine. The delay is provided at block 416 to allow the engine to reach a consistent rotational speed before it is read at block 418. This allows the controller 102 to obtain and use an accurate reading.

[0057] At block 420, the controller 102 determines if the speed (rpm) of the engine is either greater than or equal to a pre-set/ threshold rpm. If the rpm of the engine is either greater than or equal to the pre-set rpm, the engine is stopped at block 422 and the engine-start check is considered successful.

[0058] If the rpm of the engine is less than the pre-set rpm then, at block 424, the engine-start check is considered unsuccessful and the controller 102 can display a fault code/ indicator for informing the rider of the failure in starting the engine on the display unit provided on the dashboard vehicle. In an example, at block 426, the controller 102 can switch on a beeper for few seconds, for example for 3 seconds. The beeper produces a beeping sound to indicate the fault code to the rider. This

helps in informing the rider of the engine-start check failure so that the rider can obtain assistance. It thus helps in avoiding accidents caused due to abrupt engine start failure. Further, after the engine-start check failure message is displayed, the engine is stopped, and the vehicle is activated in the determined mode of operation at block 422.

[0059] Fig. 5 illustrates a dashboard 116 of the vehicle. The dashboard 116 may include a variety of components to indicate to the rider about the various operating parameters of the vehicle. In one example implementation, the dashboard 116 of the vehicle uses a Liquid crystal display (LCD) based display. In another implementation, the dashboard 116 of the vehicle may use a thin film transistor (TFT) based display. The dashboard 116 can comprise a battery SOC indicator 502, a fuel level indicator 504, a low fuel indicator 506, a malfunction indicator 508, a range indicator 510, an area for displaying text messages 512, etc. The battery SOC indicator 502 can indicate the available state of charge of the battery for operating the vehicle in the electric drive mode. The fuel level indicator 504 can indicate the availability of fuel in the fuel tank for operating the engine of the vehicle. The low fuel indicator 506 can indicate the level of fuel in the fuel tank. The malfunction indicator 508 can indicate any fault in the functioning of the vehicle.

[0060] The range indicator 510 can indicate a distance that the vehicle can travel with the available state of charge and available level of fuel. For instance, in an example, the range indicator 510 indicates the distance the vehicle is capable of traveling in an electric drive limp home mode or an engine limp home mode. In another example, the range indicator 510 can indicate the distance, the vehicle can travel in a pure electric drive mode, in which the vehicle is operated only using battery and electric motor. Similarly, the range indicator 510 is also capable of indicating the distance the vehicle can travel using engine as the only source of power. The range indicator 510, in another example, can also indicate the combined distance the vehicle can travel using both the available sources of power. For example, the range indicator 510 on the dashboard 116 can be toggled using a toggle key to navigate to the different range indications for the different modes of

operation. In an example, the dashboard 116 can display text about engine-start check, failure in the engine self-start, malfunction in the engine, etc.

[0061] Thus, the systems and methods of the present subject matter can check and ensure the start-ability of the engine before each ride and help in avoiding accidents or other safety issues caused due to engine start failure. Further, the rider can be proactively informed about the failure of engine before activating the hybrid or electric drive mode of operation of the vehicle, so that the rider can be prompted to get technical support for servicing the engine.

[0062] Although the subject matter has been described in considerable detail with reference to certain examples and implementations thereof, other implementations are possible. As such, the scope of the present subject matter should not be limited to the description of the preferred examples and implementations contained therein.

I/We claim:

1. A method for performing an engine-start check for a hybrid vehicle (106) comprising an engine (108) and a battery operated motive power source (114), the method comprising:

determining that the hybrid vehicle (106) is to be activated in a hybrid mode of operation or an electric drive mode of operation based on a fuel level in a fuel tank (110) and a state of charge of a battery (112) of the hybrid vehicle (106);

starting the engine (108) prior to activating the hybrid vehicle (106) in the hybrid mode of operation or the electric drive mode of operation;

comparing an engine speed of the engine (108) with a threshold engine speed to perform the engine-start check;

determining whether the engine-start check is successful based on the comparison; and

stopping the engine (108) and activating the hybrid vehicle (106) on completion of the engine-start check to operate the hybrid vehicle (106) in the determined mode of operation.

2. The method as claimed in claim 1, wherein starting the engine (108) comprises:

identifying an ignition map based on an engine oil temperature;

cranking the engine (108) by a starter motor; and

operating the engine (108) based on the ignition map.

3. The method as claimed in claim 2, wherein identifying the ignition map comprises:

selecting a base ignition map when the engine oil temperature is greater than a threshold temperature; and

selecting a heating ignition map when the engine oil temperature is not greater than the threshold temperature.

4. The method as claimed in claim 3, comprising actuating a cold start solenoid for cold starting the engine (108) when the engine oil temperature is not greater than the threshold temperature.

5. The method as claimed in claim 1, comprising comparing the engine speed with the threshold engine speed after expiry of a delay time from a time of starting the engine (108).

6. The method as claimed in claim 1, comprising

indicating engine start failure when the engine speed is less than the threshold engine speed; and

indicating engine start success when the engine speed is not less than the threshold engine speed.

7. The method as claimed in claim 6, wherein indicating the engine start success or engine start failure comprises providing one or more of an audio signal, a text message on a display, a colored lighted symbol on the display, and a light indicator.

8. The method as claimed in claim 1, wherein determining that the hybrid vehicle (106) is to be activated in the hybrid mode of operation or the electric drive mode of operation comprises:

determining that a throttle position of the hybrid vehicle (106) corresponds to idling, an activation switch of the hybrid vehicle (106) is switched ON, and a brake switch of the hybrid vehicle (106) is switched ON;

obtaining the fuel level and the battery state of charge;

comparing the fuel level with a threshold fuel level and the battery state of charge with a threshold battery state of charge; and

determining a mode of operation for activating the hybrid vehicle (106) as:

immobile when the fuel level is less than the threshold fuel level and the battery state of charge is less than the threshold battery state of charge;

the hybrid mode of operation when the fuel level is not less than the threshold fuel level and the battery state of charge is not less than the threshold battery state of charge;

the engine mode of operation when the fuel level is not less than the threshold fuel level and the battery state of charge is less than the threshold battery state of charge, wherein in the engine mode of operation, the battery operated motive power source (114) is to be operable in a limp home mode; and

an electric drive mode of operation when the fuel level is less than the threshold fuel level and the battery state of charge is not less than the threshold battery state of charge, wherein in the electric drive mode of operation, the engine (108) is to be operable in the limp home mode.

9. The method as claimed in claim 8, comprising determining an estimated running distance for the determined mode of operation and displaying the mode of operation and estimated running distance.

10. A system (100) for performing engine-start check for a hybrid vehicle (106), the system (100) comprising a controller (102) to:

determine that the hybrid vehicle (106) is to be activated in a hybrid mode of operation or an electric drive mode of operation based on a fuel level in a fuel tank (110) and a state of charge of a battery (112) of the hybrid vehicle (106);

start the engine (108) prior to activating the hybrid vehicle (106) in the hybrid mode of operation or the electric drive mode of operation;

compare an engine speed of the engine (108) with a threshold engine speed to perform the engine-start check, wherein the controller (102) is to

compare the engine speed with the threshold engine speed after expiry of a delay time from a time of starting the engine (108);

determine whether the engine-start check is successful based on the comparison; and

stop the engine (108) and activate the hybrid vehicle (106) in the determined mode of operation on completion of the engine-start check.

11. The system (100) as claimed in claim 10, wherein the system comprises an ignition control unit (104) and wherein, to start the engine (108),

the ignition control unit (104) is to select a base ignition map or a heating ignition map based on an engine oil temperature; and

the controller (102) is to crank the engine (108) by a starter motor and operate the engine (108) based on the ignition map.

12. The system (100) as claimed in claim 10, comprising a dashboard (116), wherein the controller (102) is to indicate engine start failure through the dashboard (116) when the engine speed is less than the threshold engine speed and indicate engine start success through the dashboard (116) when the engine speed is not less than the threshold engine speed.

13. The system (100) as claimed in claim 10, wherein, to determine that the hybrid vehicle (106) is to be activated in the hybrid mode of operation or the electric drive mode of operation, the controller (102) is to:

determine that a throttle position of the hybrid vehicle (106) corresponds to idling, an activation switch of the hybrid vehicle (106) is switched ON, and a brake switch of the hybrid vehicle (106) is switched ON;

obtain the fuel level and the battery state of charge;

compare the fuel level with a threshold fuel level and the battery state of charge with a threshold battery state of charge; and

determine a mode of operation for activating the hybrid vehicle (106) as:

immobile when the fuel level is less than the threshold fuel level and the battery state of charge is less than the threshold battery state of charge;

the hybrid mode of operation when the fuel level is not less than the threshold fuel level and the battery state of charge is not less than the threshold battery state of charge;

the engine mode of operation when the fuel level is not less than the threshold fuel level and the battery state of charge is less than the threshold battery state of charge, wherein in the engine mode of operation, the battery operated motive power source (114) is to be operable in a limp home mode; and

an electric drive mode of operation when the fuel level is less than the threshold fuel level and the battery state of charge is not less than the threshold battery state of charge, wherein in the electric drive mode of operation, the engine (108) is to be operable in the limp home mode.

14. The system (100) as claimed in claim 13, wherein the controller (102) is to determine an estimated running distance on determining the mode of operation and display the mode of operation and the running distance on a dashboard (116) of the hybrid vehicle (106).

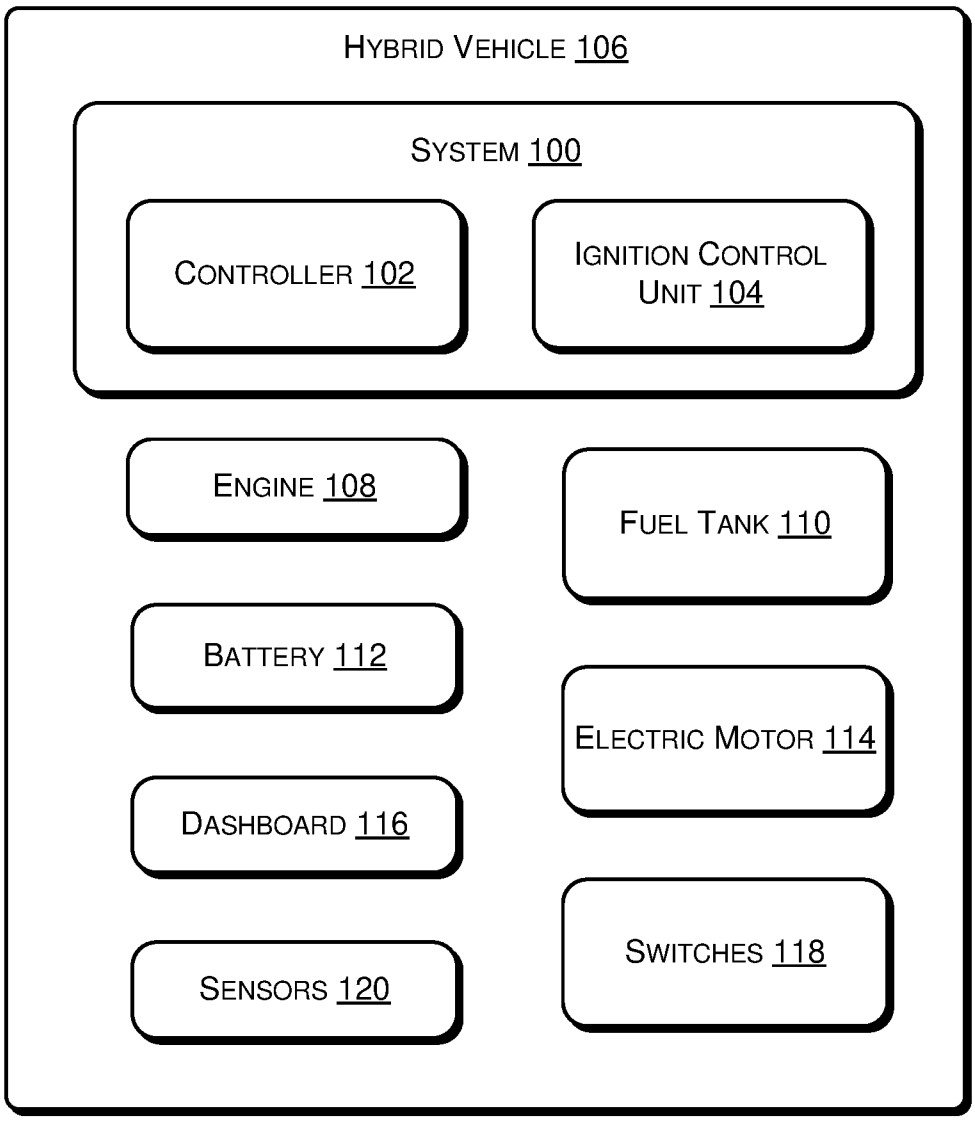
HYBRID VEHICLE 106
SYSTEM 100
CONTROLLER 102
IGNITION CONTROL UNIT 104
ENGINE 108
FUEL TANK 110
BATTERY 112
ELECTRIC MOTOR 114
DASHBOARD 116
SWITCHES 118
SENSORS 120

Fig. 1

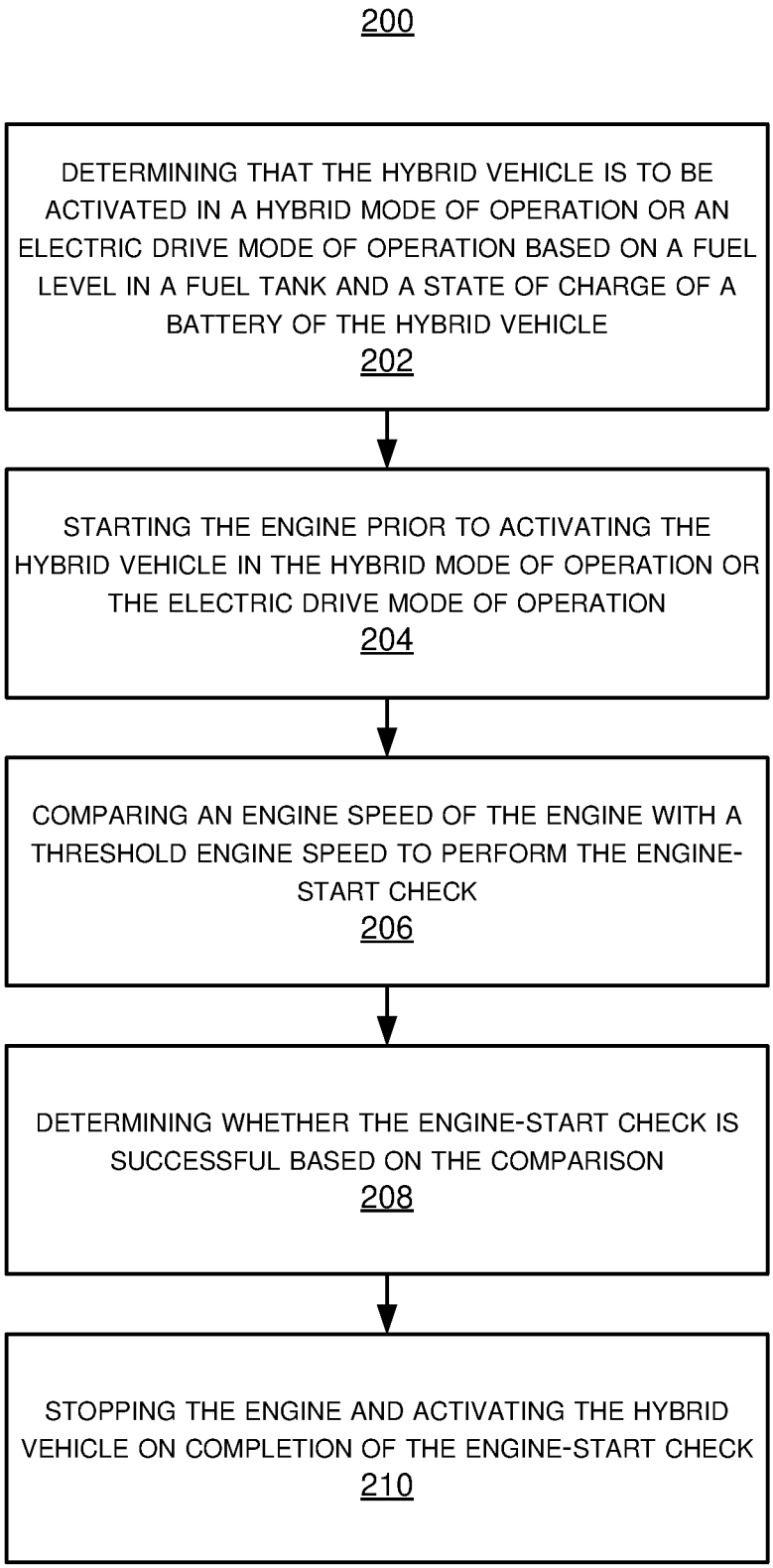
200
DETERMINING THAT THE HYBRID VEHICLE IS TO BE ACTIVATED IN A HYBRID MODE OF OPERATION OR AN ELECTRIC DRIVE MODE OF OPERATION BASED ON A FUEL LEVEL IN A FUEL TANK AND A STATE OF CHARGE OF A BATTERY OF THE HYBRID VEHICLE
202
STARTING THE ENGINE PRIOR TO ACTIVATING THE HYBRID VEHICLE IN THE HYBRID MODE OF OPERATION OR THE ELECTRIC DRIVE MODE OF OPERATION
204
COMPARING AN ENGINE SPEED OF THE ENGINE WITH A THRESHOLD ENGINE SPEED TO PERFORM THE ENGINE-START CHECK
206
DETERMINING WHETHER THE ENGINE-START CHECK IS SUCCESSFUL BASED ON THE COMPARISON
208
STOPPING THE ENGINE AND ACTIVATING THE HYBRID VEHICLE ON COMPLETION OF THE ENGINE-START CHECK
210

Fig. 2

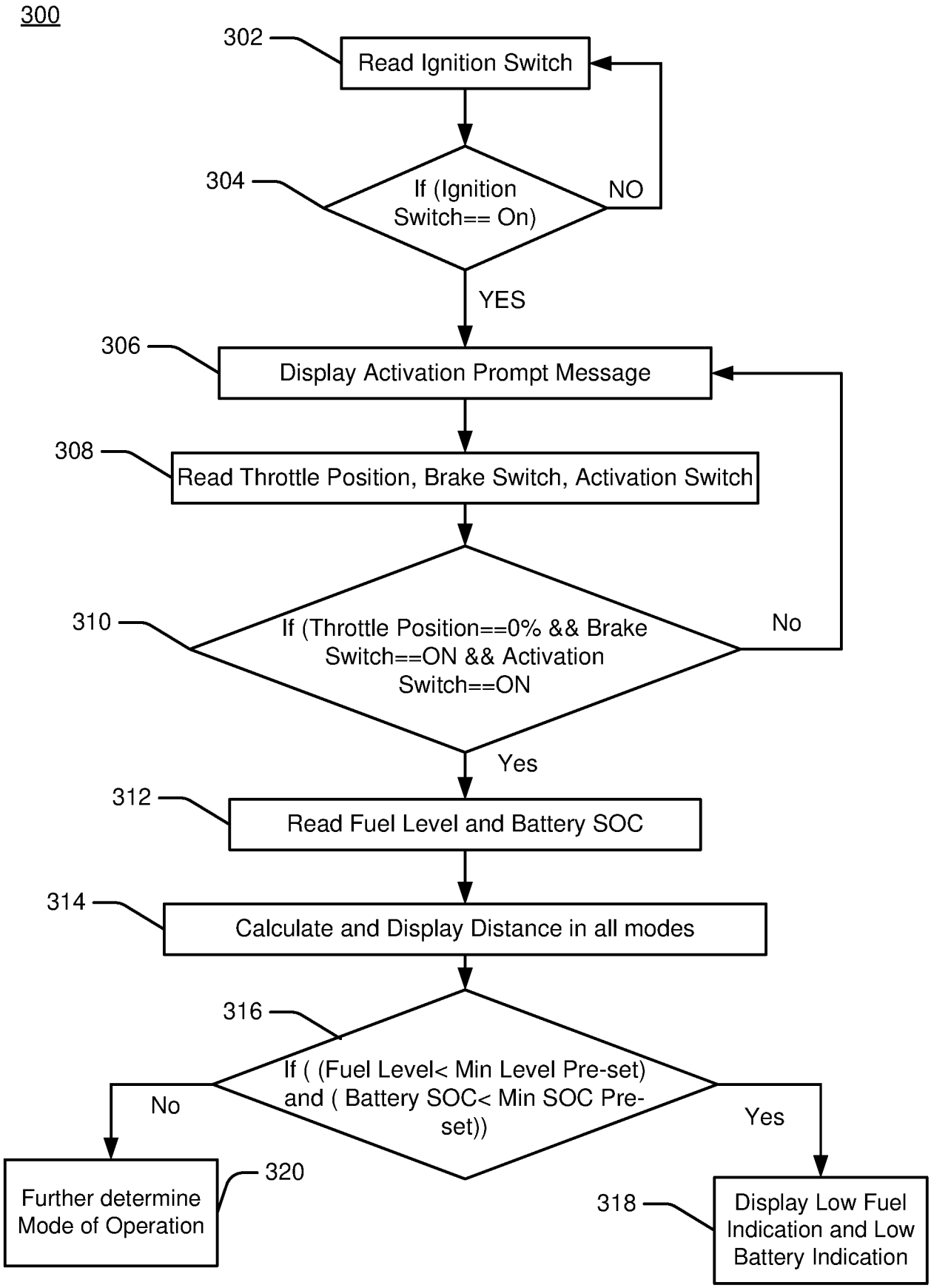
300
302
Read Ignition Switch
304
If (Ignition Switch== On)
NO
YES
306
Display Activation Prompt Message
308
Read Throttle Position, Brake Switch, Activation Switch
310
If (Throttle Position==0% && Brake Switch==ON && Activation Switch==ON
No
Yes
312
Read Fuel Level and Battery SOC
314
Calculate and Display Distance in all modes
316
If ((Fuel Level< Min Level Pre-set) and (Battery SOC< Min SOC Pre-set))
No
Yes
320
Further determine Mode of Operation
318
Display Low Fuel Indication and Low Battery Indication

Fig. 3a

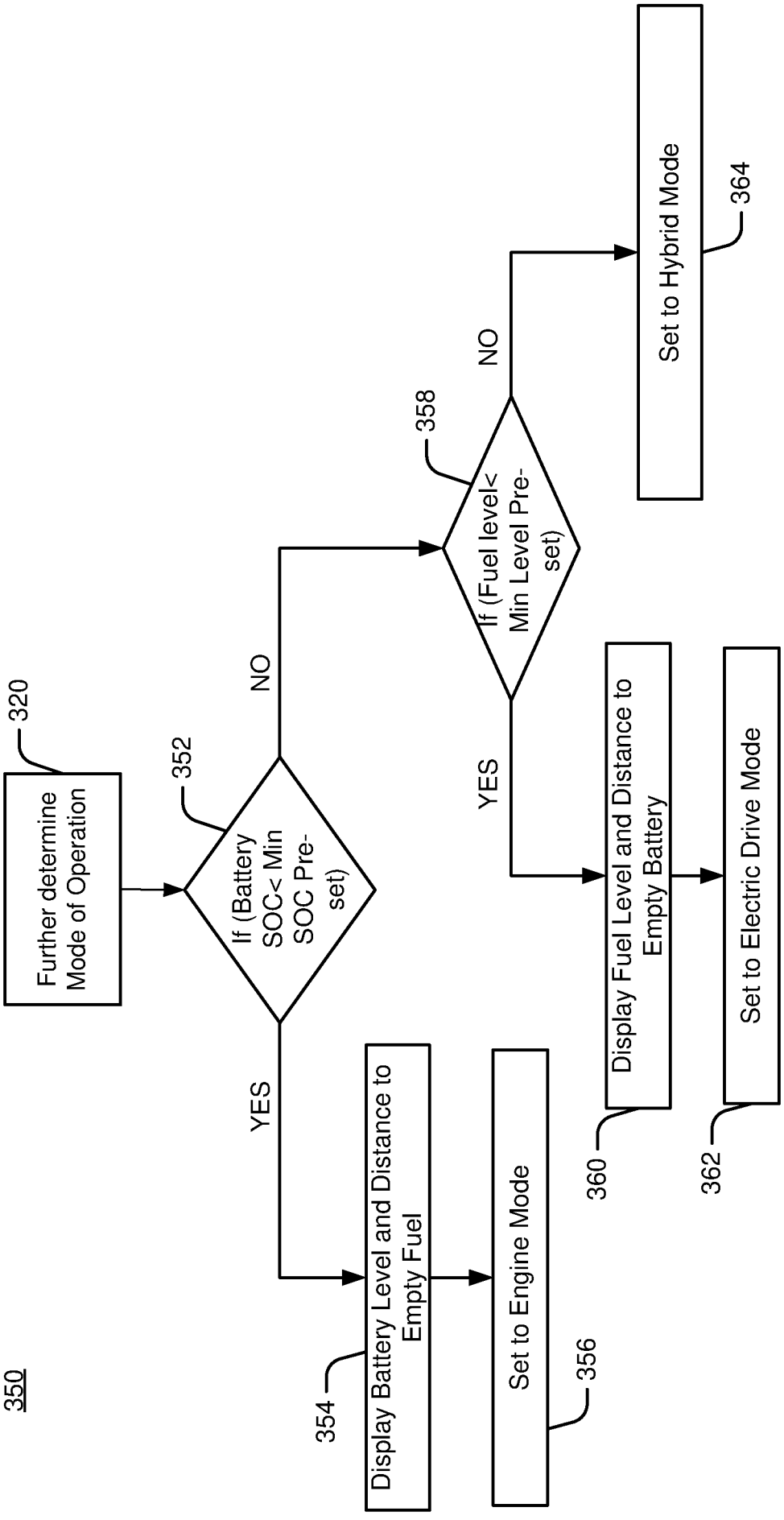
350
320
Further determine Mode of Operation
352
If (Battery SOC< Min SOC Pre-set)
YES
NO
354
Display Battery Level and Distance to Empty Fuel
356
Set to Engine Mode
358
If (Fuel level< Min Level Pre-set)
YES
NO
360
Display Fuel Level and Distance to Empty Battery
362
Set to Electric Drive Mode
364
Set to Hybrid Mode

Fig. 3b

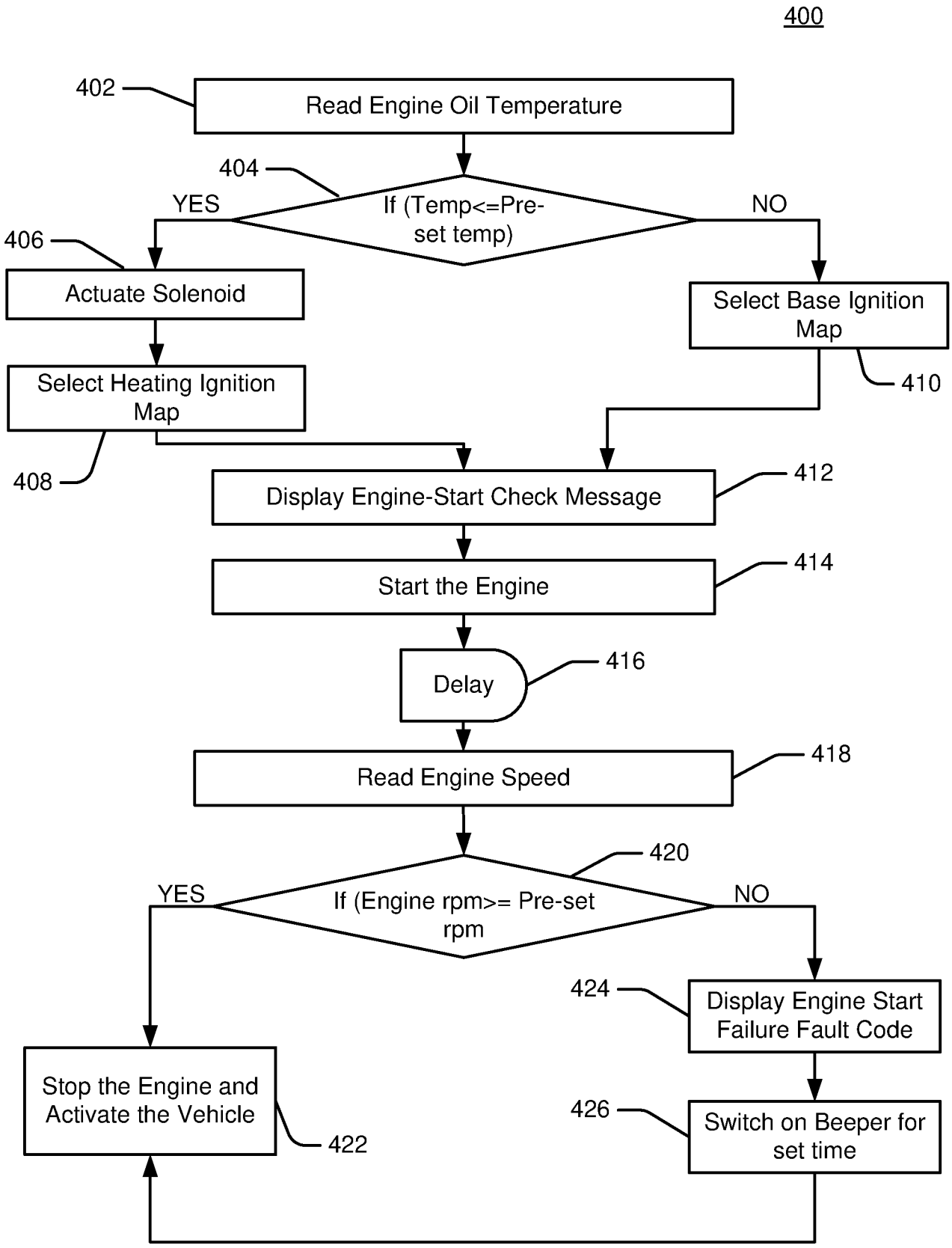
400
402
Read Engine Oil Temperature
404
If (Temp<=Pre-set temp)
YES
NO
406
Actuate Solenoid
Select Base Ignition Map
410
Select Heating Ignition Map
408
412
Display Engine-Start Check Message
414
Start the Engine
416
Delay
418
Read Engine Speed
420
If (Engine rpm>= Pre-set rpm
YES
NO
424
Display Engine Start Failure Fault Code
Stop the Engine and Activate the Vehicle
422
426
Switch on Beeper for set time

Fig. 4

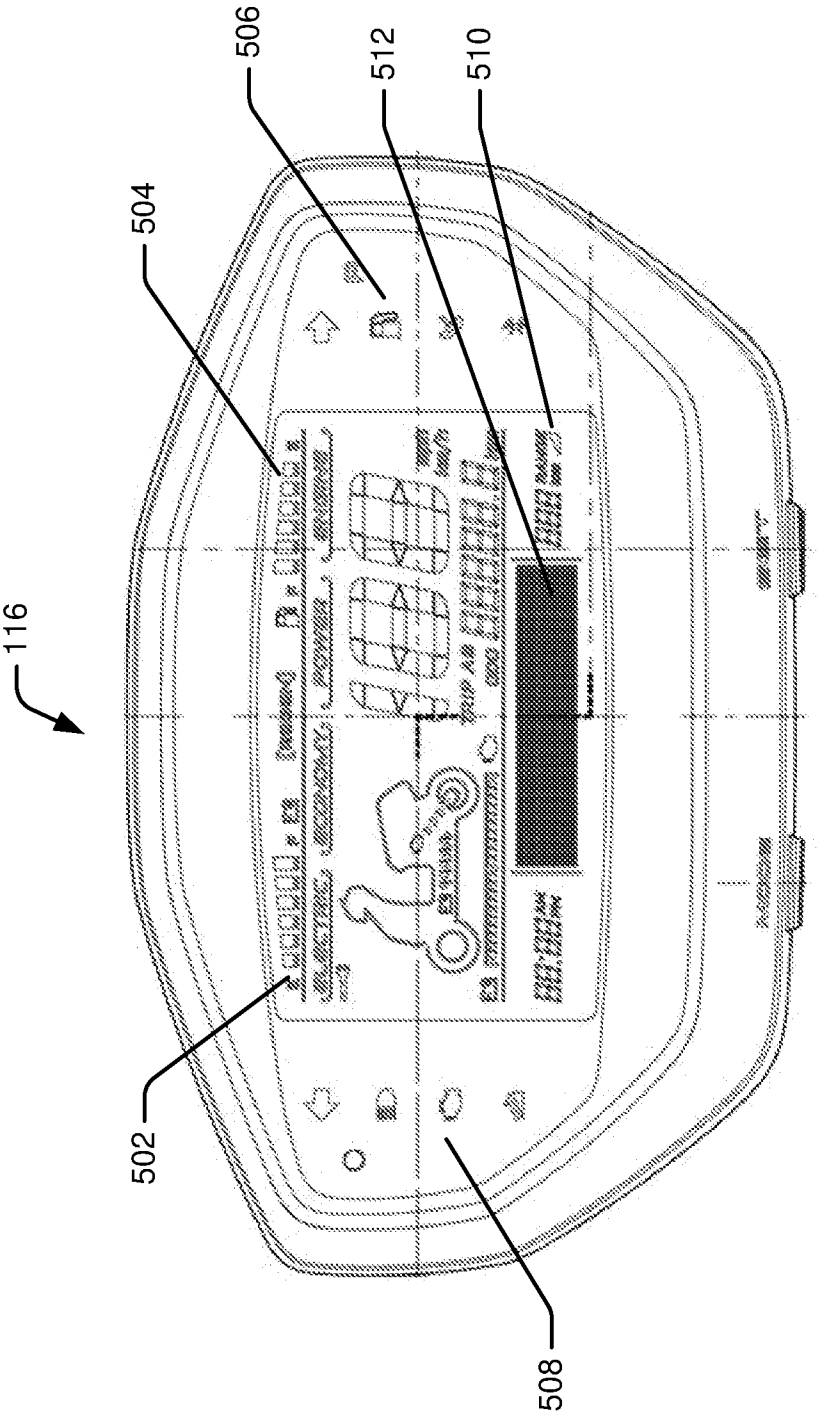

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2020/050305

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K6/20 B60W10/06 B60W10/08 B60W10/26 B60W10/24
B60W20/20 B60W20/50 B60W30/192 B60W50/14 B60W50/08
B60W60/00 B60W50/029

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)
B60K B60W

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2016 119715 A1 (HYUNDAI MOTOR CO LTD [KR]) 14 June 2017 (2017-06-14) claims 1-10; figures 3a-4b	1-14
A	US 10 183 675 B2 (TOYOTA MOTOR CO LTD [JP]) 22 January 2019 (2019-01-22) the whole document	1-14
A	DE 10 2014 015852 A1 (AUDI AG [DE]) 28 April 2016 (2016-04-28) the whole document	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 June 2020	02/07/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Vena, Gianpiero

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IN2020/050305

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