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(71) Applicant(s):
Jaguar Cars Limited
(Incorporated in the United Kingdom)
Abbey Road, Whitley, COVENTRY, Warwickshire, CV3 4LF, United Kingdom

(72) Inventor(s):
Andrew Raftry

(74) Agent and/or Address for Service:
Jaguar Land Rover
Patent Department W/1/073, Abbey Road, Whitley, COVENTRY, CV3 4LF, United Kingdom

(54) Title of the Invention: **Vehicle and method of controlling a vehicle**
Abstract Title: **Hybrid vehicle controller verifies that engine torque corresponds to demanded torque**

(57) A vehicle, e.g. a hybrid vehicle which may operate in parallel mode or electric mode, comprises a controller 140 which monitors a position of an accelerator pedal 162. The accelerator pedal 162 outputs, via a cruise control system, a signal used by the controller 140 to control at least one prime mover, e.g. combustion engine 121and motor/generator 123, to develop an amount of torque to drive the vehicle. An accelerometer measures a rate of acceleration of the vehicle and the controller 140 determines whether the measured rate of acceleration of the vehicle corresponds to that expected for the position of the accelerator pedal 162. If the measured rate of acceleration corresponds to a higher rate of acceleration the vehicle is arranged to reduce the amount of drive torque applied to one or more wheels of the vehicle. In some arrangements the vehicle is arranged to terminate the supply of torque to the wheels.

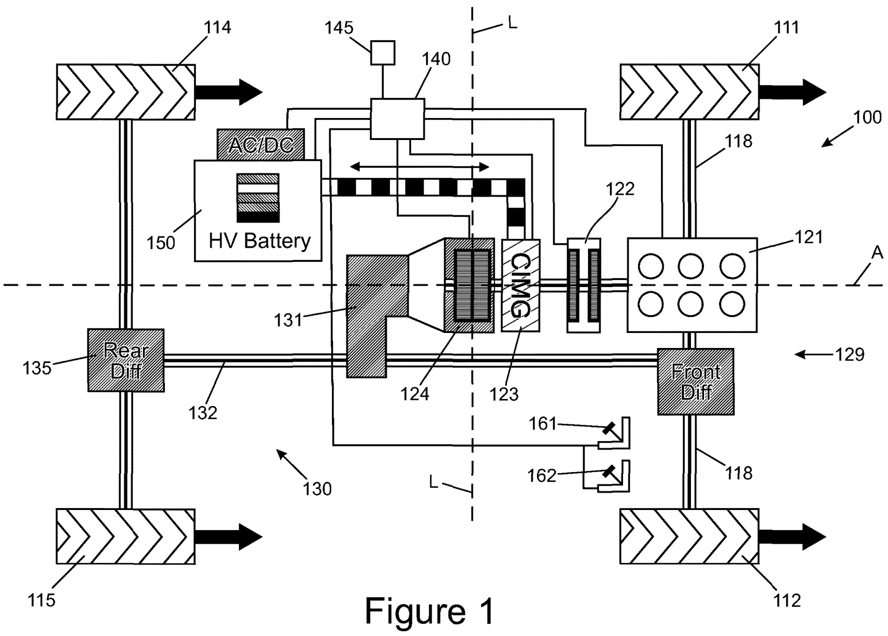

Figure 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

10 10 12

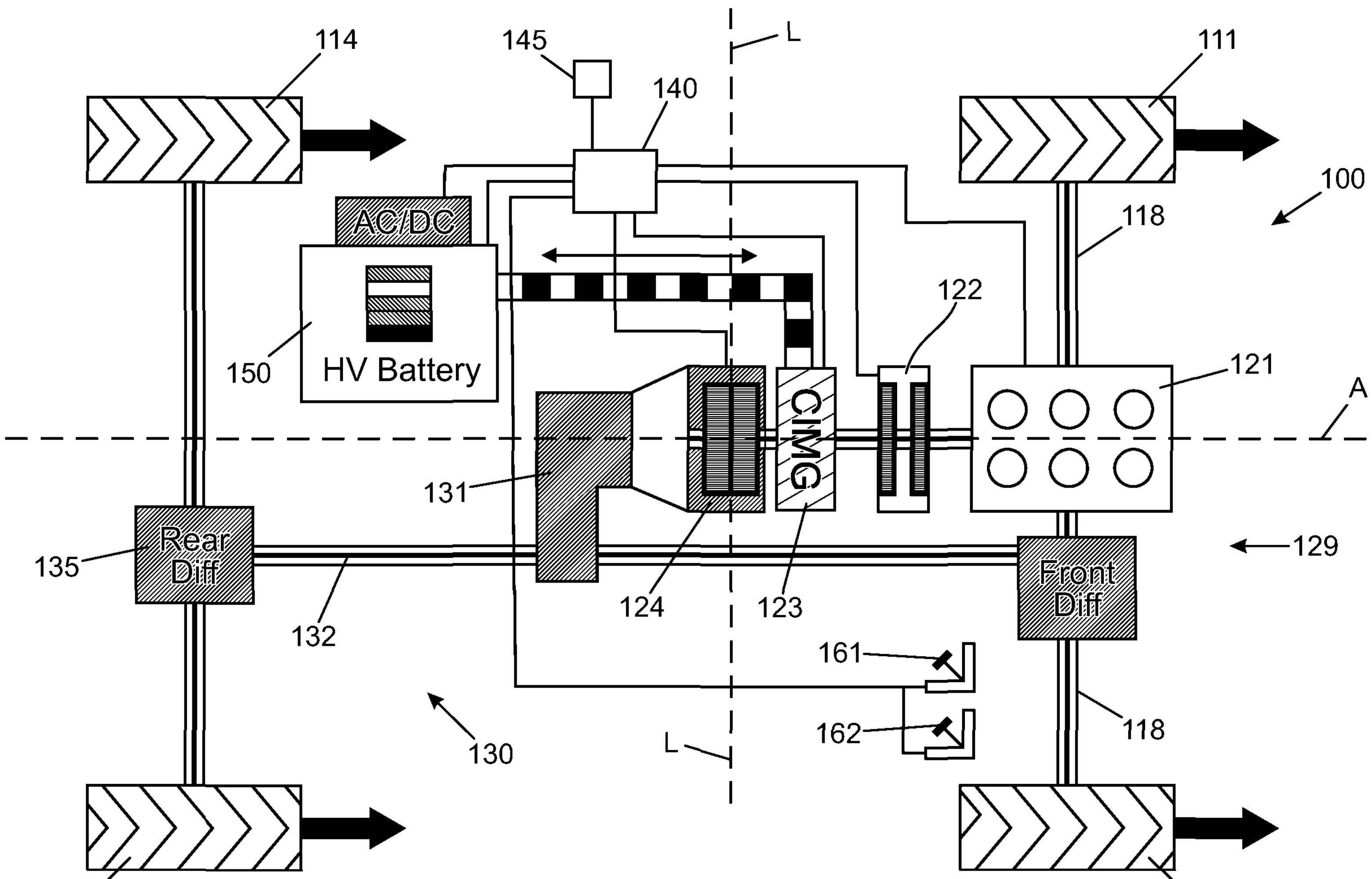

Figure 1

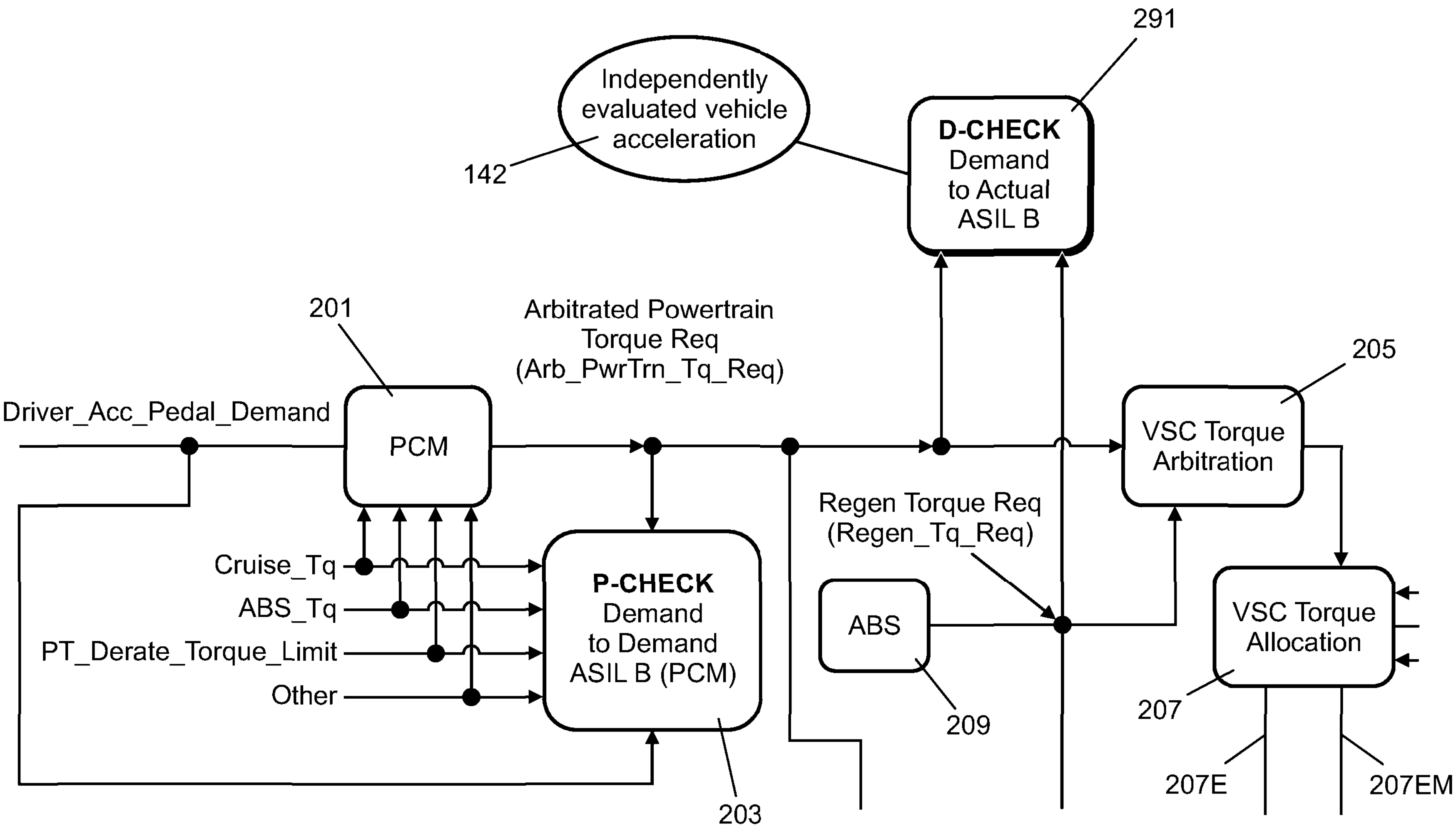
Independently evaluated vehicle acceleration
142
291
D-CHECK Demand to Actual ASIL B
201
Arbitrated Powertrain Torque Req (Arb_PwrTrn_Tq_Req)
205
Driver_Acc_Pedal_Demand
PCM
VSC Torque Arbitration
Regen Torque Req (Regen_Tq_Req)
Cruise_Tq
ABS_Tq
PT_Derate_Torque_Limit
Other
P-CHECK Demand to Demand ASIL B (PCM)
ABS
VSC Torque Allocation
209
207
203
207E
207EM

Figure 2

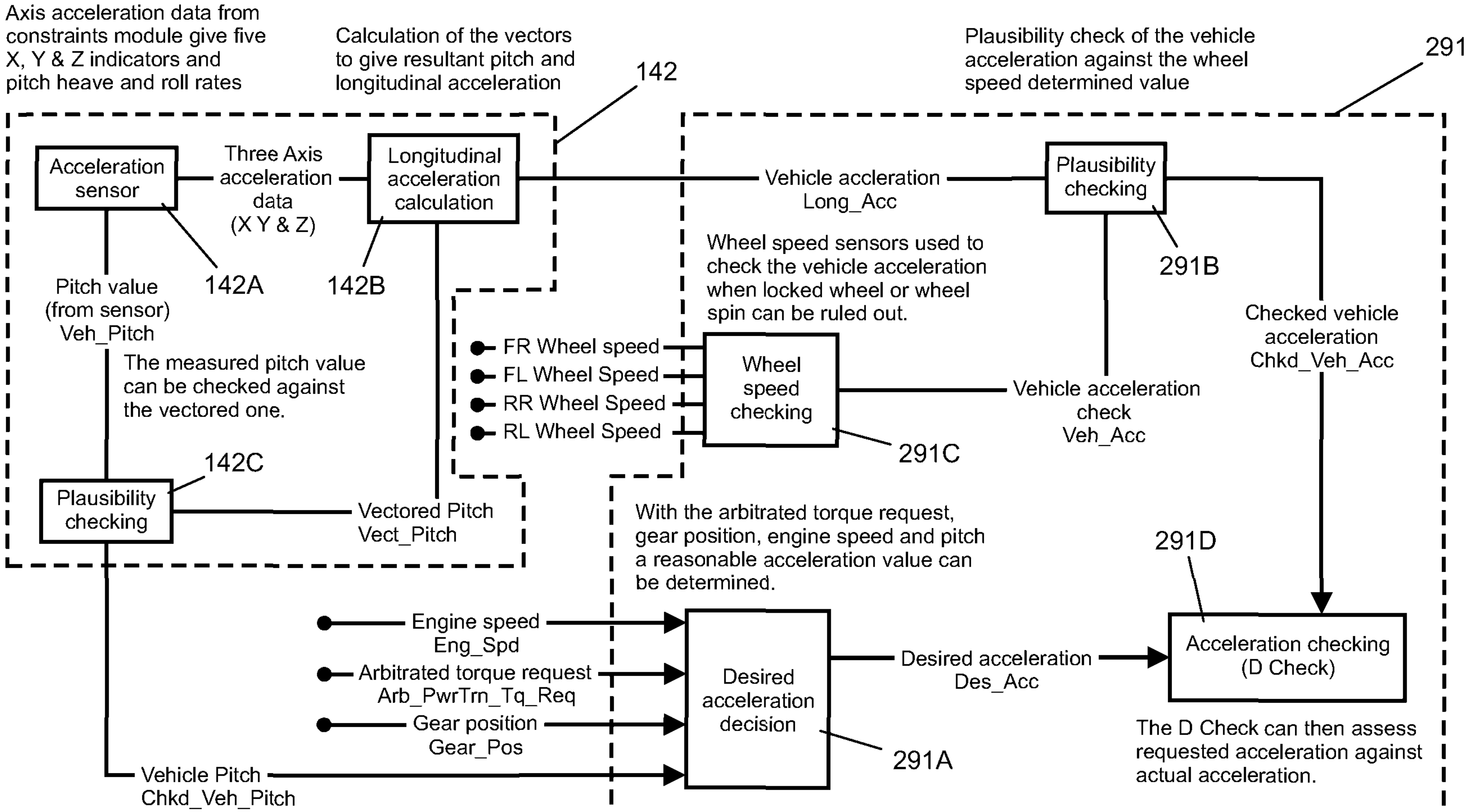
Axis acceleration data from constraints module give five X, Y & Z indicators and pitch heave and roll rates
Calculation of the vectors to give resultant pitch and longitudinal acceleration
142
Plausibility check of the vehicle acceleration against the wheel speed determined value
291
Acceleration sensor
Three Axis acceleration data (X Y & Z)
Longitudinal acceleration calculation
142A
142B
Pitch value (from sensor) Veh_Pitch
The measured pitch value can be checked against the vectored one.
142C
Plausibility checking
Vectored Pitch Vect_Pitch
Vehicle accleration Long_Acc
Plausibility checking
291B
Wheel speed sensors used to check the vehicle acceleration when locked wheel or wheel spin can be ruled out.
FR Wheel speed
FL Wheel Speed
RR Wheel Speed
RL Wheel Speed
Wheel speed checking
291C
Vehicle acceleration check Veh_Acc
Checked vehicle acceleration Chkd_Veh_Acc
With the arbitrated torque request, gear position, engine speed and pitch a reasonable acceleration value can be determined.
291D
Engine speed Eng_Spd
Arbitrated torque request Arb_PwrTrn_Tq_Req
Gear position Gear_Pos
Vehicle Pitch Chkd_Veh_Pitch
Desired acceleration decision
291A
Desired acceleration Des_Acc
Acceleration checking (D Check)
The D Check can then assess requested acceleration against actual acceleration.

Figure 3

VEHICLE AND METHOD OF CONTROLLING A VEHICLE

FIELD OF THE INVENTION

The present invention relates to apparatus and a method for controlling a vehicle. In particular but not exclusively the invention relates to an apparatus and a method of detecting whether a vehicle is responding correctly to driver control commands. Aspects of the invention relate to an apparatus, to a method and to a vehicle.

BACKGROUND

It is known to provide a controller for a motor vehicle arranged to check that an amount of torque developed by an engine of the vehicle corresponds to the amount of torque demanded by a driver of the vehicle. In the event that a discrepancy is identified the controller may be arranged to reduce the amount of torque developed by the engine.

In known vehicles, the amount of torque developed by the engine is typically measured by reference to engine speed and a flow rate into the engine of either air (in the case of petrol engines) or fuel (in the case of diesel engines). The values of engine speed and flow rate are then processed by a controller to determine the amount of torque being developed. This methodology for measuring torque has been found to be cheaper and more reliable than introducing a direct means for measuring torque such as a strain gauge on a crankshaft of the engine.

With the advent of hybrid electric vehicles (HEVs) having a plurality of prime movers including an engine and an electric machine, it has become necessary to measure the torque produced by each of the prime movers in order to determine whether the amount of torque developed by the vehicle corresponds to that demanded by the driver.

STATEMENT OF THE INVENTION

According to one aspect of the invention there is provided a control system for a vehicle having at least one prime mover, the system comprising control means operable to monitor an accelerator control signal of the vehicle and to control the at least one prime mover to develop an amount of torque to drive the vehicle corresponding to the accelerator control signal, and means for measuring a rate of acceleration of the vehicle and determining whether the measured rate of acceleration of the vehicle corresponds to that expected for the value of accelerator control signal, wherein if the measured rate of acceleration corresponds to a higher rate of acceleration the control means is arranged to reduce the amount of torque applied to one or more wheels of the vehicle.

Embodiments of the invention have the advantage that the rate of acceleration of the vehicle is measured rather than the amount of torque. The rate of acceleration is measured directly and not inferred from other measurements. This is in contrast to known vehicles in which measurements of the amount of torque developed by an engine of the vehicle are made that involve a calculation based on measurement of a flow rate of fluid (air or diesel fuel) into the engine and a speed of the engine. A value of expected acceleration of the vehicle is then determined responsive to the value of torque developed by the engine.

Reference to reducing the amount of torque applied to the one or more wheels is to be understood to mean reducing the amount of torque in order to prevent the speed of the vehicle increasing due to an excess of torque provided by the at least one prime mover.

In some arrangements the at least one prime mover may be arranged to provide a reduced amount of torque to the wheels by applying a negative torque to the wheels. It is to be understood that a negative torque is considered to be a lower torque than a positive torque even if the magnitude of the negative torque is greater than the magnitude of the positive torque.

In some embodiments a negative torque may be applied automatically to the wheels by the vehicle by means of brakes of the vehicle in order to slow the vehicle or reduce the net torque applied to the wheels by the vehicle.

Optionally the control means is arranged to determine the amount of torque corresponding to the accelerator control signal responsive to a speed of the vehicle.

It is to be understood that the amount of torque required to be provided for a given accelerator control signal may be dependent on the speed of the vehicle. Thus the vehicle may be arranged to determine the amount of torque corresponding to a given accelerator control signal taking into account the speed of the vehicle.

Optionally the control means is arranged to determine the amount of torque corresponding to the accelerator control signal responsive to a speed of the at least one prime mover.

The amount of torque required to be provided for a accelerator control signal may be dependent on the speed of the at least one prime mover. Thus the vehicle may be arranged to determine the amount of torque corresponding to a given accelerator control signal taking into account the speed of the at least one prime mover.

Advantageously the vehicle may be arranged to reduce the amount of torque applied to one or more wheels of the vehicle by reducing the amount of torque developed by the at least one prime mover.

Further advantageously the vehicle may be arranged to reduce the amount of torque applied to one or more wheels of the vehicle by application of a brake.

The vehicle may be arranged to reduce the amount of torque applied to one or more wheels of the vehicle by disconnecting the at least one prime mover means from the one or more wheels.

This has the advantage that a vehicle may be permitted to coast (and be slowed by driver-initiated braking if required) in the event that unintended acceleration is encountered.

The vehicle may be arranged to reduce the amount of torque applied to one or more wheels of the vehicle by turning off the at least one prime mover means.

In embodiments of the engine having an engine and an electric machine operable as a generator or as a motor the vehicle may be arranged to turn off and/or disconnect the engine from wheels of the vehicle and apply a negative torque to the wheels by means of the electric machine.

Optionally the vehicle comprises a plurality of prime mover means.

Embodiments of the invention have the advantage that it is not required to provide a corresponding plurality of torque measuring means for measuring the amount of torque generated by each of the prime mover means. Rather, a separate independent means for verifying that the prime mover means are generating the required amount of torque is provided.

Advantageously the means for measuring the rate of acceleration of the vehicle may be independent of the control means, the means for measuring rate of acceleration being arranged to provide an output to the control means corresponding to the measured rate of acceleration.

This feature has the advantage that in the event of a malfunction of the control means and an actual amount of torque developed by the powertrain exceeds the amount of torque demanded by the driver the vehicle may detect the malfunction and take action in response.

Advantageously the means for measuring the rate of acceleration of the vehicle may comprise an accelerometer.

The means for measuring the rate of acceleration of the vehicle may be arranged to determine acceleration of the vehicle in a direction parallel to a direction of travel of the vehicle.

Advantageously the vehicle may be arranged to determine whether the accelerator control signal corresponds to the measured rate of acceleration in the direction parallel to the direction of travel by taking into account vehicle attitude thereby to compensate for an effect of gravity on vehicle acceleration when the vehicle is on an inclined surface.

By attitude is meant an angle of pitch of the vehicle. Thus, if the vehicle is on a substantially horizontal surface the pitch will correspond to a 'level attitude' or substantially zero pitch.

If the vehicle is facing uphill on an incline, the angle of pitch will be positive, corresponding to a positive vehicle attitude, i.e. a front portion of the vehicle is raised.

Optionally the vehicle is arranged to determine whether the accelerator control signal corresponds to the measured rate of acceleration by taking into account a yaw rate of the vehicle.

Advantageously the accelerator control signal may be provided by one selected from amongst a driver operated foot pedal or hand-operated control.

Optionally the vehicle comprises a cruise control system operable to provide the accelerator control signal.

According to another aspect of the invention there is provided a vehicle having a control system as set out in one or more of the preceding paragraphs.

According to a further aspect of the invention there is provided a method of controlling a vehicle comprising the steps of: monitoring an accelerator control signal of the vehicle; control at least one prime mover of the vehicle to develop an amount of torque corresponding to the accelerator control signal, measuring a rate of acceleration of the vehicle; and determining whether the accelerator control signal corresponds to the measured rate of acceleration of the vehicle; in the event that the measured rate of acceleration corresponds to a higher rate of acceleration the method comprising reducing the amount of torque applied to one or more wheels of the vehicle.

According to a still further aspect of the invention there is provided a vehicle comprising: at least one prime mover; and control means operable to monitor an accelerator control signal of the vehicle and to control the at least one prime mover to develop an amount of torque corresponding to the accelerator control signal, the vehicle further comprising means for measuring a rate of acceleration of the vehicle and determining whether the measured rate of acceleration of the vehicle corresponds to the accelerator control signal, in the event that the measured rate of acceleration corresponds to a higher rate of acceleration the vehicle being arranged to reduce the amount of torque applied to one or more wheels of the vehicle.

Within the scope of this application it is envisaged that the various aspects, embodiments, examples, features and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings may be taken independently or in any combination thereof. For example, features disclosed in connection with one embodiment are applicable to all embodiments, unless there is incompatibility of features.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying figures in which:

FIGURE 1 is a schematic illustration of a vehicle according to an embodiment of the invention;

FIGURE 2 is a schematic illustration of a flow of control signals in the vehicle of FIG. 1; and

FIGURE 3 is a schematic illustration of a flow of control signals in a D-Check function block of the vehicle of FIG. 1.

DETAILED DESCRIPTION

Embodiments of the invention are particularly suited to hybrid electric vehicles although it is to be understood that the invention is not limited to a hybrid electric vehicle. For example embodiments of the invention may be used in a non-hybrid vehicle such as an electric vehicle not having an internal combustion engine. Alternatively embodiments of the invention may be used in a conventional vehicle having only a fuel-fired actuator such as an internal combustion engine, a gas turbine engine or any other suitable engine.

FIG. 1 shows a hybrid electric vehicle (HEV) 100 according to an embodiment of the present invention. The HEV 100 has an internal combustion engine 121 releasably coupled to a crankshaft integrated motor/generator (CIMG) 123 by means of a clutch 122. The CIMG 123 is in turn coupled to an automatic transmission 124. The transmission 124 is arranged to drive a pair of front wheels 111, 112 of the vehicle by means of a pair of front drive shafts 118. The vehicle 100 also has an auxiliary driveline 130 arranged to drive a pair of rear wheels 114, 115 by means of an auxiliary driveshaft 132 and a rear differential 135.

A battery 150 is provided that may be coupled to the CIMG 123 in order to allow the CIMG 123 to generate torque when the CIMG 123 is operated as a motor. Alternatively the battery 150 may be coupled to the CIMG 123 to receive charge from the CIMG 123 when the CIMG 123 is operated as a generator in order to recharge the battery 150.

The vehicle 100 is configured to operate in a parallel mode or an electric vehicle (EV) mode.

In the parallel mode of operation the clutch 122 is closed and the engine 121 is arranged to provide torque to the transmission 124 in a substantially direct coupling through the CIMG 123. In this mode the CIMG 123 may be operated either as a motor or as a generator. The CIMG 123 may be operated as a motor in order to 'boost' the torque delivered to the transmission 124 by the engine 121. The CIMG 123 may alternatively be operated as a generator to generate charge to charge the battery. If the CIMG 123 is operated as a generator to recharge the battery 150 whilst the engine 121 is delivering torque to the transmission 124 the vehicle 100 may be said to be operating in a 'parallel recharge' mode. It is to be understood that the CIMG 123 applies a negative torque loading on the engine 121 in order to generate charge to charge the battery 150.

In the EV mode of operation the clutch 122 is opened and the engine 121 is turned off. Again, the CIMG 123 is then operated either as a motor or as a generator. It is to be understood that the CIMG 123 may be arranged to act as a generator in EV mode in order to effect regenerative braking of the vehicle.

The vehicle 100 has an accelerator pedal 162 by means of which the driver may demand a required amount of torque to drive the vehicle 100. A controller 140 controls the vehicle 100 to provide the demanded torque from the engine 121 and/or CIMG 123 according to an energy management program (EMP) executed by the controller 140.

A brake pedal 161 is provided by means of which the driver may apply negative torque to the wheels. The negative torque is provided by a regenerative braking arrangement in which the CIMG 123 applies a negative torque to the wheels when required. If the amount of regenerative braking available from the CIMG 123 is insufficient to meet the driver demanded brake torque the vehicle 100 is arranged to deploy friction brakes to slow the vehicle 100.

The controller 140 is arranged to monitor the amount of torque demanded by the driver and to verify that the amount of torque developed by the engine 121 and CIMG 123 corresponds to the driver demanded value.

FIG. 2 is a control flow diagram of a portion of a control architecture of the vehicle 100.

A powertrain control module (PCM) 201 of the vehicle 100 is provided with an input signal Driver_Acc_Pedal_Demand corresponding to the amount by which the accelerator pedal 162 of the vehicle 100 has been depressed by the driver. It is to be understood that this signal corresponds to the value of torque that the driver is demanding the vehicle 100 to produce in order to propel the vehicle 100.

The PCM 201 also receives a cruise control system (CCS) torque request signal, Cruise_Tq, an anti-lock braking system (ABS) regenerative torque request signal, Regen_Tq_Req, and a powertrain derate torque limit signal PT_Derate_Torque_Limit.

The Cruise_Tq signal provides an indication of an amount of torque demanded by the cruise control system. The ABS Regen_Tq_Req signal provides an indication of the amount of regenerative torque demanded by the ABS system, i.e. an amount of negative torque to be applied to one or more wheels of the vehicle by the CIMG 123 in order to slow the vehicle 100 and generate charge to recharge the battery 150.

The PT_Derate_Torque_Limit signal provides an indication of a limit of the total amount of torque that may be provided by the engine 121 and CIMG 123. It is to be understood that the total amount of torque may be reduced under certain circumstances, for example if the CIMG 123 is at a temperature at which it is unable (or not permitted) to provide its normal maximum amount of torque. Thus if the CIMG 123 is at a temperature above a certain threshold temperature the vehicle 100 may be arranged to limit the amount of torque that may be demanded of it in order to prevent damage and/or premature ageing of the CIMG 123.

The PCM 201 outputs an arbitrated value of a powertrain torque request signal Arb_PwrTrn_Tq_Req responsive to the input signals. The arbitrated value corresponds to the actual value of torque required to be provided by the powertrain. That is, the total amount of torque that is to be provided by the engine 121 and/or CIMG 123. The arbitrated value Arb_PwrTrn_Tq_Req is provided to a P-Check function block 203, a VSC torque arbitration function block 205 and a D-Check function block 291.

The P-Check function block 203 is implemented by the controller 140. The P-Check function block 203 receives the signals input to the PCM noted above including the Driver_Acc_Pedal_Demand signal, Cruise_Tq signal, Regen_Tq_Req signal and PT_Derate_Torque_Limit signal.

If the vehicle is operating in cruise control mode the P-Check function block 203 determines whether the value of Arb_PwrTrn_Tq_Req corresponds to the value of torque requested by the cruise control system. If the vehicle is not operating in cruise control mode the P-Check function block 203 determines whether the value of Arb_PwrTrn_Tq_Req corresponds to the value of torque demanded by the driver, i.e. the value corresponding to the Driver_Acc_Pedal_Demand signal.

If the value of Arb_PwrTrn_Tq_Req exceeds any of these values, the P-Check function block 203 is arranged to limit the amount of torque provided by the engine 121 and CIMG 123. In some arrangements the engine 121 and CIMG 123 are shut down. In some embodiments the P-check function block 203 is configured to force a reset of the controller 140. In some embodiments the P-Check function block 203 is arranged to limit the amount of positive torque provided by the engine 121 and CIMG 123 to wheels of the vehicle 100.

Similarly, the P-Check function block 203 also checks that the value of Arb_PwrTrn_Tq_Req does not exceed any constraint imposed by the PT_Derate_Torque_Limit signal.

An ABS controller 209 also provides the regenerative torque request signal Regen_Tq_Req to the VSC torque arbitration function block 205 and to a D-Check function block 291.

The VSC torque arbitration function block 205 compares the value of the arbitrated powertrain torque request signal Arb_PwrTrn_Tq_Req with the value of the Regen_Tq_Req signal and determines a total amount of torque that is to be demanded from the engine 121 and/or CIMG 123, depending on whether one or both of the engine 121 and CIMG 123 are to provide torque. A decision as to which of the engine 121 and

CIMG 123 are to provide torque and the amount of torque each is to provide is made by a VSC torque allocation function block 207.

The D-Check function block 291 is implemented in a module separate from the controller 140 and PCM 201. The D-check function block 291 is arranged to receive an input signal from an accelerometer device 142 that is arranged to measure a proper acceleration of the device 142 and therefore of the vehicle 100. The accelerometer device 142 may be a gyroscopic-type accelerometer device, a piezoelectric-type accelerometer device, a micro-electromechanical system (MEMS)-type device or any other suitable accelerometer device 142.

The D-Check function block 291 is arranged to determine a forward acceleration of the vehicle 100 by correcting the value of acceleration provided by the accelerometer device 142 by reference to one or more signals indicating vehicle attitude and yaw rate.

The D-Check function block 291 is arranged to calculate a desired acceleration of the vehicle responsive to the values of the arbitrated powertrain torque request signal Arb_PwrTrn_Tq_Req and Regen_Tq_Req signal. The D-Check function block 291 compares the calculated acceleration with the value of forward acceleration determined responsive to the signal received from the accelerometer device 142 in order to determine whether the actual acceleration of the vehicle 100 corresponds to the value expected based on the value of the Arb_PwrTrn_Tq_Req and Regen_Tq_Req signals.

For example, if the value of Arb_PwrTrn_Tq_Req corresponds to a torque of 300Nm and the value of Regen_Tq_Req corresponds to a torque of 100Nm, the net positive torque provided by the engine 121 to the wheels will be 200Nm. The D-Check function block 291 is therefore arranged to calculate a desired acceleration of the vehicle 100 based on a net torque of 200Nm applied to the wheels. It is to be understood that the 100Nm of regenerative torque is a torque loading placed on the engine 121 by the CIMG 123 in order to generate electrical power to charge the battery 150.

If the acceleration measured responsive to the signal received from the accelerometer device 142 is greater than that which would be expected based on the value of Arb_PwrTrn_Tq_Req and Regen_Tq_Req the D-Check function block 291 is arranged to provide an alert signal to reduce the amount of torque developed by the engine 121 and/or CIMG 123. In some embodiments the D-Check function block 291 is arranged to reduce the amount of torque generated by the engine 121 and CIMG 123 to zero and disconnect the engine 121 and CIMG 123 from the wheels of the vehicle.

In some embodiments the D-Check function block 291 is arranged to place the engine 121 and CIMG 123 in a condition in which they cannot generate torque. In some embodiments the D-Check function block 291 is arranged to disable the engine 121 and CIMG 123 such that they cannot be operated.

Embodiments of the present invention have the advantage that if a value of actual acceleration of the vehicle 100 exceeds that which would be expected based on the value of Arb_PwrTrn_Tq_Req the vehicle 100 is arranged to reduce the amount of torque applied to driven wheels of the vehicle 100. Embodiments of the invention have the advantage that an independent and direct check of vehicle acceleration may be performed independently of any indirect measurements of an amount of torque developed by one or more prime movers of the vehicle 100.

FIG. 3 shows in more detail a configuration of the accelerometer device 142 and the D-Check function block 291.

The accelerometer device 142 has a 6-axis acceleration sensor 142A arranged to provide an output corresponding to a rate of acceleration experienced by the device 142 along each of three orthogonal axes X, Y, Z. The sensor 142A also provides an output corresponding to a rate of rotation of the sensor 142A about each axis (corresponding to a rate of roll, pitch and yaw respectively).

It is to be understood that in some embodiments an accelerometer may be employed that is not a 6-axis accelerometer. For example a 3-axis accelerometer providing values of acceleration along each of the three axes X, Y, Z may be employed.

The rate of acceleration along the X, Y and Z axes is input to a longitudinal acceleration calculation function block 142B arranged to determine a resultant pitch of the vehicle Vect_Pitch responsive to the rates of acceleration along each of axes X, Y, Z (i.e. acceleration vectors parallel to the respective axes) and a value of longitudinal acceleration Long_Acc of the vehicle. By longitudinal acceleration is meant an actual overall acceleration of the vehicle 100 parallel to a surface over which the vehicle is driving, i.e. the value of acceleration parallel to the longitudinal axis A of the vehicle (parallel to axis X) corrected for pitch (rotation about a lateral axis L of the vehicle, L passing through the centre of gravity COG of the vehicle 100).

The acceleration sensor 142A outputs the measured value of pitch rate (i.e. rate of change of pitch) Veh_Pitch to a plausibility checking function block 142C which compares the value of Veh_Pitch with the value Vect_Pitch calculated by the longitudinal acceleration calculation function block 142B. This is in order to check that the values are consistent with one another. If the values are not consistent with one another the checking function block 142C is arranged to provide an output signal corresponding to a fault code. The vehicle 100 may be configured to provide an output to the driver responsive to the fault code, for example a service request output. In some embodiments the vehicle may be configured to reconfigure one or more portions of the controller 140 responsive to the fault code.

It is to be understood that in embodiments not having a 6-axis acceleration sensor 142A arranged to output a value Veh_Pitch the function block 142C may not be provided.

The value of Veh_Pitch is output by function block 142C as signal Chkd_Veh_Pitch to a desired acceleration decision function block 291A of the D-Check function block 291. The decision function block 291A also receives as input signals a signal corresponding to the engine speed, Eng_Spd, the Arb_PwrTrn_Tq_Req signal and a signal corresponding to the currently selected gear ratio, Gear_Pos, being in the present example a signal corresponding to the currently selected gear. The decision function block 291A is configured to determine an estimate of the rate of acceleration desired by the driver of the vehicle responsive to the input signals. A signal Des_Acc corresponding to this estimated rate is output to an acceleration checking function block 291D.

It is to be understood that the decision function block 291A takes into account the value of Chkd_Veh_Pitch when calculating the value of Des_Acc so that if the vehicle 100 is on an incline, the value of desired (i.e. expected) acceleration may be corrected to take into account a positive or negative acceleration force due to gravity. Thus if the vehicle 100 is travelling forwards up a hill the value of actual acceleration for a given amount of torque supplied by the engine 121 and/or CIMG 123 may be expected to be less than if the vehicle were travelling forwards on a level surface. Similarly, if the vehicle 100 is travelling forwards down a hill the value of actual acceleration may be expected to be greater than if it is travelling on a level surface or up a hill.

It is to be understood that the value of Des_Acc may also take into account an actual loading on the powertrain, due to vehicle weight and the weight of any object being towed. The loading may be determined by the PCM 201 or any other suitable means. In some embodiments the desired acceleration decision function block 291A assumes the vehicle is operating at a prescribed (fixed) loading on the powertrain. Vehicle load may be calculated by the PCM 201 based on a flow rate of air or fuel into the engine 121.

The value of Long_Acc calculated by the longitudinal acceleration calculation function block 142B is output to a plausibility checking function block 291B of the D-Check function block 291. The value of Long_Acc is compared by function block 291B with a vehicle acceleration value Veh_Acc determined by a wheel speed checking function block 291C. The wheel speed checking function block 291C receives as inputs a speed of each of the four wheels 111, 112, 114, 115 and determines a rate of acceleration of the vehicle 100 responsive to the measured wheel speeds.

The plausibility checking function block 291B outputs the value of Long_Acc as a checked value of vehicle acceleration Chkd_Veh_Acc to the acceleration checking function block 291D.

If the plausibility checking function block 291B determines that the value of Veh_Acc (determined responsive to wheel speeds) is not consistent with the value of Long_Acc (determined responsive to acceleration measured by acceleration sensor 142A) the function block 291B terminates checking and provides a warning signal. The function block 291B is configured to resume checking as new input data becomes available.

In some embodiments the block 291B continues to output the value Long_Acc as the parameter Chkd_Veh_Acc even if it terminates checking and provides the warning signal due to a mismatch so that the acceleration checking function block 291D can continue functioning.

The acceleration checking function block 291D compares the value of Des_Acc with the value of Chkd_Veh_Acc. If the function block 291D determines that the value of Chkd_Veh_Acc exceeds the value of Des_Acc by more than a prescribed amount the function block 291D provides an alert signal to a vehicle controller area network (CAN) responsive to which the amount of torque generated by the engine 121 and CIMG 123 is reduced substantially to zero. In some arrangements the transmission 124 is controlled to disconnect the engine 121 and CIMG 123 from the wheels 111, 112, 114, 115 of the vehicle 100.

Thus it is to be understood that in some embodiments the vehicle 100 is configured to respond in a relatively dramatic manner to a determination that the value of actual acceleration, Chkd_Veh_Acc is greater than the value of desired vehicle acceleration Des_Acc, i.e. by reducing the amount of torque developed by the engine 121 and CIMG 123 to zero.

In some alternative embodiments, in the event that a discrepancy is identified in which the actual acceleration Chkd_Veh_Acc is greater than the desired value Des_Acc the vehicle 100 is configured to reduce the value of Arb_PwrTrn_Tq_Req accordingly in order to reduce the value of Chkd_Veh_Acc closer to the value of Des_Acc.

With the increase in interest in hybrid electric vehicles having a plurality of torque sources conventional methods of checking actual torque developed by a prime mover against demanded torque are becoming increasingly complex to implement. Embodiments of the present invention enable an independent check of vehicle response to torque applied by a powertrain to wheels of a vehicle thereby to reduce a risk that a vehicle accelerates in a manner unintended by the driver. In some embodiments an independent check of vehicle response to torque applied by a powertrain (including one or more prime movers and brakes of the vehicle) to wheels of a vehicle thereby to reduce a risk that a vehicle accelerates in a manner unintended by the driver.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

CLAIMS:

1. A vehicle comprising:

at least one prime mover;

control means operable to monitor an accelerator control signal of the vehicle and to control the at least one prime mover to develop an amount of torque to drive the vehicle corresponding to the accelerator control signal; and

means for measuring a rate of acceleration of the vehicle and determining whether the measured rate of acceleration of the vehicle corresponds to that expected for the value of accelerator control signal;

wherein, if the measured rate of acceleration corresponds to a higher rate of acceleration than the expected acceleration, the control means is arranged to reduce the amount of torque applied to one or more wheels of the vehicle.

2. A vehicle as claimed in claim 1 wherein the control means is arranged to determine the amount of torque corresponding to the accelerator control signal responsive to a speed of the vehicle.

3. A vehicle as claimed in claim 1 or claim 2 wherein the control means is arranged to determine the amount of torque corresponding to the accelerator control signal responsive to a speed of the at least one prime mover.

4. A vehicle as claimed in any preceding claim arranged to reduce the amount of torque applied to one or more wheels of the vehicle by reducing the amount of torque developed by the at least one prime mover.

5. A vehicle as claimed in any preceding claim arranged to reduce the amount of torque applied to one or more wheels of the vehicle by application of a brake.

6. A vehicle as claimed in any preceding claim arranged to reduce the amount of torque applied to one or more wheels of the vehicle by disconnecting the at least one prime mover means from the one or more wheels.

7. A vehicle as claimed in any preceding claim arranged to reduce the amount of torque applied to one or more wheels of the vehicle by turning off the at least one prime mover means.

8. A vehicle as claimed in any preceding claim comprising a plurality of prime mover means.

9. A vehicle as claimed in any preceding claim wherein the means for measuring the rate of acceleration of the vehicle is independent of the control means, the means for measuring rate of acceleration being arranged to provide an output to the control means corresponding to the measured rate of acceleration.

10. A vehicle as claimed in any preceding claim wherein the means for measuring the rate of acceleration of the vehicle comprises an accelerometer.

11. A vehicle as claimed in any preceding claim wherein the means for measuring the rate of acceleration of the vehicle is arranged to determine acceleration of the vehicle in a direction parallel to a direction of travel of the vehicle.

12. A vehicle as claimed in claim 11 arranged to determine whether the accelerator control signal corresponds to the measured rate of acceleration in the direction parallel to the direction of travel by taking into account vehicle attitude thereby to compensate for an effect of gravity on vehicle acceleration when the vehicle is on an inclined surface.

13. A vehicle as claimed in any preceding claim arranged to determine whether the accelerator control signal corresponds to the measured rate of acceleration by taking into account a yaw rate of the vehicle.

14. A vehicle as claimed in any preceding claim wherein the accelerator control signal is provided by one selected from amongst a driver operated foot pedal or hand-operated control.

15. A vehicle as claimed in any preceding claim comprising a cruise control system operable to provide the accelerator control signal.

16. A method of controlling a vehicle comprising:

monitoring an accelerator control signal of the vehicle;

controlling at least one prime mover of the vehicle to develop an amount of torque corresponding to the accelerator control signal;

measuring a rate of acceleration of the vehicle;

determining whether the accelerator control signal corresponds to the measured rate of acceleration of the vehicle; and

if the measured rate of acceleration corresponds to a higher rate of acceleration, reducing the amount of torque applied to one or more wheels of the vehicle.

17. A vehicle substantially as hereinbefore described with reference to the accompanying drawings.

18. A method substantially as hereinbefore described with reference to the accompanying drawings.

Application No:	GB1111798.3	**Examiner:**	Mike McKinney
Claims searched:	1 to 18	**Date of search:**	14 November 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	EP0748959 A3 (HONDA MOTOR CO LTD)
A	-	US2002/029913 A1 (ITO et al)
A	-	EP1052132 A2 (HONDA MOTOR CO LTD)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B60W

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B60W	0030/14	01/01/2006
B60W	0010/06	01/01/2006
B60W	0010/08	01/01/2006
B60W	0020/00	01/01/2006
B60W	0050/04	01/01/2006
B60W	0050/08	01/01/2006