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AXLE TORQUE GRADE ASSIST

Abstract

A vehicle includes a system that performs a method of operating the vehicle. The system includes a road grade sensor for measuring a road grade of a road section being traversed by the vehicle, a speedometer for measuring a vehicle speed, a power flow direction sensor for obtaining a power flow direction of the vehicle, a pedal position sensor for measuring a pedal position, and a processor. The processor is configured to determine an axle torque upper limit for a motor of the vehicle based on the road grade, the vehicle speed and the power flow direction, determine an axle torque request based on the vehicle speed and the pedal position, determine a clipped axle torque request from the axle torque request and the axle torque upper limit, and control the vehicle by implementing the clipped axle torque request at the vehicle.

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Background/Summary

INTRODUCTION

[0001] The subject disclosure relates to operation of a vehicle and, in particular, to a system and method for adjusting a torque limit for torque applied to an axle of a vehicle.

[0002] Electric vehicles can be used in different scenarios. In many scenarios, vehicles are used over long driving intervals with few stops. In other scenarios, some vehicles experience short driving intervals with many stops and starts during their use. Such scenarios with short driving intervals include uses such as a delivery van or delivery truck, use as a taxi or ride-sharing vehicle. This type of start-and-stop driving leads to wear on the vehicle, such as tire wear, mount wear, axle wear, etc. In order to counteract these effects, a static limit is applied to the vehicle to limit the amount of torque that can be applied to the axles of the vehicle. However, when the vehicle is on a hill or road grade, this limit impedes the performance of the delivery vehicle. Accordingly, it is desirable to provide a method for adjusting a limit for axle torque to account for the effects of road grade.

SUMMARY

[0003] In one exemplary embodiment, a method of operating a vehicle is disclosed. A road grade of a road section being traversed by the vehicle is measured using a road grade sensor located on the vehicle. An axle torque upper limit for a motor of the vehicle is determined based on the road grade, a vehicle speed and a power flow direction of the vehicle. An axle torque request is determined based on the vehicle speed and a pedal position. A clipped axle torque request is determined from the axle torque request and the axle torque upper limit. The vehicle is controlled by implementing the clipped axle torque request at the vehicle.

[0004] In addition to one or more of the features described herein, the clipped axle torque request is a minimum value of the axle torque request and the axle torque upper limit.

[0005] In addition to one or more of the features described herein, wherein the power flow direction is in a forward gear, the method further includes determining the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having an upper grade threshold, a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold, and the first value when the road grade is negative.

[0006] In addition to one or more of the features described herein, wherein the power flow direction is in a reverse gear, the method further includes determining the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having a lower grade threshold, the first value when the road grade is positive, and a second value greater than the first value when the road grade is negative and less than the lower grade threshold.

[0007] In addition to one or more of the features described herein, the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill.

[0008] In addition to one or more of the features described herein, further including selecting a default road grade value when at least one of a road grade measurement is not valid and the power flow direction is not valid.

[0009] In addition to one or more of the features described herein, the road grade sensor is an accelerometer.

[0010] In another exemplary embodiment, a system for operating a vehicle is disclosed. The system includes a road grade sensor for measuring a road grade of a road section being traversed by the vehicle, a speedometer for measuring a vehicle speed, a power flow direction sensor for obtaining a power flow direction of the vehicle, a pedal position sensor for measuring a pedal position, and a processor. The processor is configured to determine an axle torque upper limit for a motor of the vehicle based on the road grade, the vehicle speed and the power flow direction, determine an axle torque request based on the vehicle speed and the pedal position, determine a clipped axle torque request from the axle torque request and the axle torque upper limit, and control the vehicle by implementing the clipped axle torque request at the vehicle.

[0011] In addition to one or more of the features described herein, the processor is further configured to determine the clipped axle torque request as a minimum value of the axle torque request and the axle torque upper limit.

[0012] In addition to one or more of the features described herein, the power flow direction is in a forward gear and the processor is further configured to determine the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having an upper grade threshold, a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold, and the first value when the road grade is negative.

[0013] In addition to one or more of the features described herein, the power flow direction is in a reverse gear and the processor is further configured to determine the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having a lower grade threshold, the first value when the road grade is positive, and a second value greater than the first value when the road grade is negative and less than the lower grade threshold.

[0014] In addition to one or more of the features described herein, the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill.

[0015] In addition to one or more of the features described herein, the processor is further configured to select a default road grade value when at least one of a road grade measurement is not valid and the power flow direction is not valid.

[0016] In addition to one or more of the features described herein, the road grade sensor is an accelerometer.

[0017] In yet another exemplary embodiment, a vehicle is disclosed. The vehicle includes a road grade sensor for measuring a road grade of a road section being traversed by the vehicle, a speedometer for measuring a vehicle speed, a power flow direction sensor for obtaining a power flow direction of the vehicle, a pedal position sensor for measuring a pedal position, and a processor. The processor is configured to determine an axle torque upper limit for a motor of the vehicle based on the road grade, the vehicle speed and the power flow direction, determine an axle torque request based on the vehicle speed and the pedal position, determine a clipped axle torque request from the axle torque request and the axle torque upper limit, and control the vehicle by implementing the clipped axle torque request at the vehicle.

[0018] In addition to one or more of the features described herein, the processor is further configured to determine the clipped axle torque request as a minimum value of the axle torque request and the axle torque upper limit.

[0019] In addition to one or more of the features described herein, the power flow direction is in a forward gear and the processor is further configured to determine the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having an upper grade threshold, a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold, and the first value when the road grade is negative.

[0020] In addition to one or more of the features described herein, the power flow direction is in a reverse gear and the processor is further configured to determine the axle torque upper limit at one of a first value when the road grade is within a zero-grade range having a lower grade threshold, the first value when the road grade is positive, and a second value greater than the first value when the road grade is negative and less than the lower grade threshold.

[0021] In addition to one or more of the features described herein, the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill.

[0022] In addition to one or more of the features described herein, the processor is further configured to select a default road grade value when at least one of a road grade measurement is not valid and the power flow direction is not valid.

[0023] The above features and advantages, and other features and advantages of the disclosure are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Other features, advantages and details appear, by way of example only, in the following detailed description, the detailed description referring to the drawings in which:

[0025] FIG. **1** shows an embodiment of a vehicle, in an exemplary embodiment,

[0026] FIG. **2** shows a relation between axle torque upper limit and road grade for a vehicle in forward gear, in an illustrative embodiment;

[0027] FIG. **3** shows three road grades being traversed by an electric vehicle with its drive unit in forward gear;

[0028] FIG. **4** shows a relation between axle torque limit and road grade for a vehicle in forward gear, in an illustrative embodiment;

[0029] FIG. **5** shows the three road grades being traversed by the electric vehicle with its drive unit in reverse gear;

[0030] FIG. **6** is a schematic diagram of a process flow for implementing an axle torque limit based on road grade, in an illustrative embodiment; and

[0031] FIG. **7** is a flowchart of a method for implementing a clipped axle torque request at the electric vehicle.

DETAILED DESCRIPTION

[0032] The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features. As used herein, the term module refers to processing circuitry that may include an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that executes one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

[0033] In accordance with an exemplary embodiment, FIG. **1** shows an embodiment of a vehicle **10**, which includes a vehicle body **12** defining, at least in part, an occupant compartment **14**. The vehicle body **12** also supports various vehicle subsystems including a propulsion system **16**, and other subsystems to support functions of the propulsion system **16** and other vehicle components, such as a braking subsystem, a suspension system, a steering subsystem, and others.

[0034] The vehicle **10** may be an electrically powered vehicle (EV), an internal combustion engine vehicle, a hybrid vehicle or any other type of vehicle. For illustrative purposes, the vehicle **10** is an electric vehicle that includes multiple motors and/or drive systems. Any number of drive units may be included, such as one or more drive units for applying torque to front wheels (not shown) and/or to rear wheels (not shown). The drive units are controllable to operate the vehicle **10** in various operating modes, such as a normal mode, a high-performance mode (in which additional torque is applied), all-wheel drive (“AWD”), front-wheel drive (“FWD”), rear-wheel drive (“RWD”) and others.

[0035] For example, the propulsion system **16** is a multi-drive system that includes a front drive unit **20** for driving front wheels, and rear drive units for driving rear wheels. The front drive unit **20** includes a front electric motor **22** and a front inverter **24** (e.g., front power inverter module or FPIM), as well as other components such as a cooling system. A left rear drive unit **30**L includes a left rear electric motor **32**L and a left rear inverter **34**L. A right rear drive unit **30**R includes a right rear electric motor **32**R and a right rear inverter **34**R. The front inverter **24**, left rear inverter **34**L and right rear inverter **34**R (e.g., power inverter units or PIMs) each convert direct current (DC) power from a high voltage (HV) battery system **40** to poly-phase (e.g., two-phase, three-phase, six-phase, etc.) alternating current (AC) power to drive the front electric motor **22** the left rear electric motor **32**L and the right rear electric motor **32**R.

[0036] As shown in FIG. **1**, the drive systems feature separate electric motors. However, embodiments are not so limited. For example, instead of separate motors, multiple drives can be provided by a single machine that has multiple sets of windings that are physically independent.

[0037] As also shown in FIG. **1**, the drive systems are configured such that the front electric motor **22** drives the front wheels (not shown), and the left rear electric motor **32**L and right rear electric motor **32**R drive the rear wheels (not shown). However, embodiments are not so limited, as there may be any number of drive systems and/or motors at various locations (e.g., a motor driving each wheel, twin motors per axle, etc.). In addition, embodiments are not limited to a dual drive system, as embodiments can be used with a vehicle having any number of motors and/or power inverters.

[0038] In the propulsion system **16**, the front drive unit **20**, left rear drive unit **30**L and right rear drive unit **30**R are electrically connected to a battery system **40**. The battery system **40** may also be electrically connected to other electrical components (also referred to as “electrical loads”), such as vehicle electronics (e.g., via an auxiliary power module or APM **42**), heaters, cooling systems and others. The battery system **40** may be configured as a rechargeable energy storage system (RESS).

[0039] In an embodiment, the battery system **40** includes a plurality of separate battery assemblies, in which each battery assembly can be independently charged and can be used to independently supply power to a drive system or systems. For example, the battery system **40** includes a first battery assembly such as a first battery pack **44** connected to the front inverter **24**, and a second battery pack **46**. The first battery pack **44** includes a plurality of battery modules **48**, and the second battery pack **46** includes a plurality of battery modules **50**. Each battery module **48**, **50** includes a number of individual cells (not shown). In various embodiments, one or more of the battery packs can include a MODACS (Multiple Output Dynamically Adjustable Capacity) battery.

[0040] Each of the front electric motor **22** and the left rear electric motor **32**L and right rear electric motor **32**R is a three-phase motor having three phase motor windings. However, embodiments described herein are not so limited. For example, the motors may be any poly-phase machines supplied by poly-phase inverters, and the drive units can be realized using a single machine having independent sets of windings.

[0041] The battery system **40** and/or the propulsion system **16** includes a switching system having various switching devices for controlling operation of the first battery pack **44** and second battery pack **46**, and selectively connecting the first battery pack **44** and second battery pack **46** to the front drive unit **20**, left rear drive unit **30**L and right rear drive unit **30**R. The switching devices may also be operated to selectively connect the first battery pack **44** and the second battery pack **46** to a charging system. The charging system can be used to charge the first battery pack **44** and the second battery pack **46**, and/or to supply power from the first battery pack **44** and/or the second battery pack **46** to charge another energy storage system (e.g., vehicle-to-vehicle (V2V) and/or vehicle-to-everything (V2X) charging). The charging system includes one or more charging modules. For example, a first onboard charging module (OBCM) **52** is electrically connected to a charge port **54** for charging to and from an AC system or device, such as a utility AC power supply. A second OBCM **53** may be included for DC charging (e.g., DC fast charging or DCFC).

[0042] In an embodiment, the switching system includes a first switching device **60** that selectively connects to the first battery pack **44** to the front inverter **24**, left rear inverter **34**L and right rear inverter **34**R, and a second switching device **62** that selectively connects the second battery pack **46** to the front inverter **24**, left rear inverter **34**L and right rear inverter **34**R. The switching system also includes a third switching device **64** (also referred to as a “battery switching device”) for selectively connecting the first battery pack **44** to the second battery pack **46** in series.

[0043] Any of various controllers can be used to control functions of the battery system **40**, the switching system and the drive units. A controller includes any suitable processing device or unit and may use an existing controller such as a drive system controller, an RESS controller, and/or controllers in the drive system. For example, a controller **65** may be included for drive control operations as discussed herein.

[0044] The controller **65** may include processing circuitry that may include an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that executes one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality. The controller **65** may include a non-transitory computer-readable medium that stores instructions which, when processed by one or more processors of the controller **65**, implement a method of determining an upper limit to axle torque than can be provided to an axle (or wheel) of the vehicle based on road grade experienced by the vehicle and controlling operation of a power train to provide an axle torque that does not exceed this upper limit, according to one or more embodiments detailed herein.

[0045] The vehicle **10** also includes a road grade sensor **70**, a power flow direction sensor **72**, a speedometer **74** and a pedal position sensor **76**. The road grade sensor **70** can be used to determine or measure a road grade of a road section being traversed by the vehicle. In various embodiments, the road grade sensor **70** is an accelerometer. The controller **65** monitors the road grade sensor **70** to determine a validity of road grade measurements. For example, a road grade measurement needs to be recorded over a sufficient amount of time to be considered valid. The power flow direction sensor **72** detects a power flow direction (i.e., forward, reverse) of the drive unit(s) of the vehicle **10**. The speedometer **74** measures a speed of the vehicle **10** (vehicle speed). The pedal position sensor **76** detects a pedal position (i.e., a position of an acceleration pedal).

[0046] The vehicle **10** also includes a computer system **55** that includes one or more processing devices **56** and a user interface **58**. The computer system **55** may communicate with the charging system controller, for example, to provide commands thereto in response to a user input. The various processing devices, modules and units may communicate with one another via a communication device or system, such as a controller area network (CAN) or transmission control protocol (TCP) bus.

[0047] FIG. **2** shows a relation **200** between axle torque upper limit and road grade for a vehicle in forward gear, in an illustrative embodiment. Road grade is shown as a percentage (%) along the abscissa and axle torque upper limit values (UL) are shown along the ordinate axis. The axle torque upper limit is shown by curve **202**. When the road grade is zero or near zero, the axle torque upper limit is at a first value (UL1), which is generally a smallest value for the limit. A zero-grade range extends from a lower grade threshold A to an upper grade threshold B. For example, a zero-grade range can extend about −5% to about +5%. For positive grades greater than the upper grade threshold, the curve **202** increases as road grade increases. An illustrative road grade is shown at C along the abscissa, which relates to a second value for the axle torque upper limit. The second value is greater than the first value. For negative grades less than the lower grade threshold, the curve **202** remains at the first value.

[0048] FIG. **3** shows three road grades being traversed by an electric vehicle with its drive unit in forward gear. In a first forward gear scenario **302**, the road grade is zero or near zero (i.e., the vehicle is on a horizontal or near-horizontal terrain) and the torque limit is set at a first value (UL1) suitable for such horizontal terrain. In a second forward gear scenario **304**, the road grade is a positive value, (i.e., the vehicle is moving uphill) and the torque limit is raised from the first value (UL1) to the second value (UL2). In a third forward gear scenario **306**, the road grade is negative (i.e., the vehicle is moving downhill) and the torque limit is maintained at the first value (UL1).

[0049] FIG. **4** shows a relation **400** between axle torque limit and road grade for a vehicle in forward gear, in an illustrative embodiment. Road grade is shown as a percentage (%) along the abscissa and axle torque upper limit values (UL) are shown along the ordinate axis. The limit is shown by curve **402**. When the road grade is zero or near zero, the axle torque upper limit is at a first value (UL1), which is generally a smallest value for the limit. For positive grades, the curve **402** remains at the first value (UL1). For negative grades, the curve **402** increases to a second value (UL2). An illustrative road grade is shown at D along the abscissa, which relates to a second value (UL2) for the axle torque upper limit. The second value (UL2) is greater than the first value (UL1).

[0050] FIG. **5** shows the three road grades being traversed by the electric vehicle with its drive unit in reverse gear. In a first reverse gear scenario **502**, the road grade is zero or near zero (i.e., the vehicle is on a horizontal or near-horizontal terrain) and the axle torque upper limit is placed at the first value (UL1). In a second reverse gear scenario **504**, the road grade is positive, (i.e., the vehicle is moving downhill) and the torque limit is maintained at the first value. In a third reverse gear scenario **506**, the road grade is negative (i.e., the vehicle is moving uphill) and the torque limit is raised from the first value (UL1) to the second value (UL2).

[0051] FIG. **6** is a schematic diagram **600** of a process flow for implementing an axle torque limit based on road grade, in an illustrative embodiment. The process flow involves operation of various modules, such as a torque request module **602**, a torque limit module **604**, and a minimization module **606**, that are performed on the processor of the controller **65**.

[0052] The torque request module **602** receives a pedal position **608** (from pedal position sensor **76**) and a vehicle speed **610** (from speedometer **74**). The torque request module **602** determines an axle torque request **612** using a pedal map that includes a mathematical relation between pedal position **608**, vehicle speed **610**, and axle torque request.

[0053] The torque limit module **604** receives a road grade percentage **614** (from road grade sensor **70**), a road grade validity signal **616** (from controller **65**), a power flow direction **618** (from power flow direction sensor **72**) and the vehicle speed **610** (from speedometer **74**). The torque limit module **604** calculates a value for an axle torque upper limit **620** based on these parameters. The axle torque upper limit **620** and the axle torque request **612** are provided to the minimization module **606** which generates a clipped axle torque request **622**. The clipped axle torque request **622** is a minimum value of the axle torque upper limit **620** and the axle torque request **612**.

[0054] FIG. **7** is a flowchart **700** of a method for implementing a clipped axle torque request **622** at the electric vehicle. The method begins at box **702**, in which a road grade is measured. In box **704**, the road grade measurement is checked for validity. If the road grade measurement is not valid, the method proceeds to box **708**. Otherwise (i.e., road grade measurement is valid), the method proceeds to box **706**. In box **706**, a power flow direction is obtained and checked for validity. If the power flow direction is not valid, the method proceeds to box **708**. Otherwise (i.e., the power flow direction is valid), the method proceeds to box **710**. In box **708**, a default road grade value is assigned as a value of a processed road grade. From box **708**, the method proceeds to box **718**, which is discussed below.

[0055] Turning to box **710**, the power flow direction is determined. If the drive unit is in forward gear, the method proceeds to box **712**. In box **712**, a sign of the road grade is maintained. In other words, a grade multiplier is set to +1. Returning to box **710**, if the drive unit is in reverse gear, the method proceeds to box **714**. In box **714**, a sign of the road grade is flipped. In other words, the grade multiplier is set to −1.

[0056] In box **718**, the grade multiplier and road grade measurement are received, the grade multiplier is received from either box **712** or box **714**. The road grade measurement is received from box **716**. In box **718**, a processed road grade is created by multiplying the road grade measurement and the grade multiplier. The processed road grade is provided to box **718**.

[0057] In box **718**, an axle torque upper limit is determined based on the processed road grade (from box **716**) and the vehicle speed **610**. The axle torque upper limit is provided to box **720**. In box **720**, the axle torque upper limit (from box **718**) and the axle torque request **612** are compared to determine a clipped axle torque request **622**. The clipped axle torque request is then implemented at the electric vehicle. The method ends at box **722**.

[0058] The terms “a” and “an” do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. The term “or” means “and/or” unless clearly indicated otherwise by context. Reference throughout the specification to “an aspect”, means that a particular element (e.g., feature, structure, step, or characteristic) described in connection with the aspect is included in at least one aspect described herein, and may or may not be present in other aspects. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various aspects.

[0059] When an element such as a layer, film, region, or substrate is referred to as being “on” another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present.

[0060] Unless specified to the contrary herein, all test standards are the most recent standard in effect as of the filing date of this application, or, if priority is claimed, the filing date of the earliest priority application in which the test standard appears.

[0061] Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this disclosure belongs.

[0062] While the above disclosure has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from its scope. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiments disclosed, but will include all embodiments falling within the scope thereof.

Claims

1. A method of operating a vehicle, comprising: measuring a road grade of a road section being traversed by the vehicle using a road grade sensor located on the vehicle; determining an axle torque upper limit for a motor of the vehicle based on the road grade, a vehicle speed and a power flow direction of the vehicle, wherein the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill in forward gear and increases as the road grade decreases when the vehicle is moving uphill in reverse gear; determining an axle torque request based on the vehicle speed and a pedal position; determining a clipped axle torque request from the axle torque request and the axle torque upper limit; and controlling the vehicle by implementing the clipped axle torque request at the vehicle.

2. The method of claim 1, wherein the clipped axle torque request is a minimum value of the axle torque request and the axle torque upper limit.

3. The method of claim 1, wherein the power flow direction is in a forward gear, further comprising determining the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having an upper grade threshold; (ii) a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold; and (iii) the first value when the road grade is negative.

4. The method of claim 1, wherein the power flow direction is in a reverse gear, further comprising determining the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having a lower grade threshold; (ii) the first value when the road grade is positive; and (iii) a second value greater than the first value when the road grade is negative and less than the lower grade threshold.

5. (canceled)

6. The method of claim 1, further comprising selecting a default road grade value when at least one of: (i) a road grade measurement is not valid; and (ii) the power flow direction is not valid.

7. The method of claim 1, wherein the road grade sensor is an accelerometer.

8. A system for operating a vehicle, comprising: a road grade sensor for measuring a road grade of a road section being traversed by the vehicle; a speedometer for measuring a vehicle speed; a power flow direction sensor for obtaining a power flow direction of the vehicle; a pedal position sensor for measuring a pedal position; and a processor configured to: determine an axle torque upper limit for a motor of the vehicle based on the road grade, the vehicle speed and the power flow direction, wherein the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill in forward gear and increases as the road grade decreases when the vehicle is moving uphill in reverse gear; determine an axle torque request based on the vehicle speed and the pedal position; determine a clipped axle torque request from the axle torque request and the axle torque upper limit; and control the vehicle by implementing the clipped axle torque request at the vehicle.
9. The system of claim 8, wherein the processor is further configured to determine the clipped axle torque request as a minimum value of the axle torque request and the axle torque upper limit.
10. The system of claim 8, wherein the power flow direction is in a forward gear and the processor is further configured to determine the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having an upper grade threshold; (ii) a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold; and (iii) the first value when the road grade is negative.
11. The system of claim 8, wherein the power flow direction is in a reverse gear and the processor is further configured to determine the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having a lower grade threshold; (ii) the first value when the road grade is positive; and (iii) a second value greater than the first value when the road grade is negative and less than the lower grade threshold.
12. (canceled)
13. The system of claim 8, wherein the processor is further configured to select a default road grade value when at least one of: (i) a road grade measurement is not valid; and (ii) the power flow direction is not valid.
14. The system of claim 8, wherein the road grade sensor is an accelerometer.
15. A vehicle, comprising: a road grade sensor for measuring a road grade of a road section being traversed by the vehicle; a speedometer for measuring a vehicle speed; a power flow direction sensor for obtaining a power flow direction of the vehicle; a pedal position sensor for measuring a pedal position; and a processor configured to: determine an axle torque upper limit for a motor of the vehicle based on the road grade, the vehicle speed and the power flow direction, wherein the axle torque upper limit increases as the road grade increases when the vehicle is moving uphill in forward gear and increases as the road grade decreases when the vehicle is moving uphill in reverse gear; determine an axle torque request based on the vehicle speed and the pedal position; determine a clipped axle torque request from the axle torque request and the axle torque upper limit; and control the vehicle by implementing the clipped axle torque request at the vehicle.
16. The vehicle of claim 15, wherein the processor is further configured to determine the clipped axle torque request as a minimum value of the axle torque request and the axle torque upper limit.
17. The vehicle of claim 15, wherein the power flow direction is in a forward gear and the processor is further configured to determine the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having an upper grade threshold; (ii) a second value greater than the first value when the road grade is a positive value greater than the upper grade threshold; and (iii) the first value when the road grade is negative.
18. The vehicle of claim 15, wherein the power flow direction is in a reverse gear and the processor is further configured to determine the axle torque upper limit at one of: (i) a first value when the road grade is within a zero-grade range having a lower grade threshold; (ii) the first value when the road grade is positive; and (iii) a second value greater than the first value when the road grade is negative and less than the lower grade threshold.

19. (canceled)

20. The vehicle of claim 15, wherein the processor is further configured to select a default road grade value when at least one of: (i) a road grade measurement is not valid; and (ii) the power flow direction is not valid.

21. The method of claim 1, further comprising determine the axle torque request using a pedal map that includes a mathematical relation between pedal position, vehicle speed and axle torque request.

22. The system of claim 8, wherein the processor is further configured to determine the axle torque request using a pedal map that includes a mathematical relation between pedal position, vehicle speed and axle torque request.

23. The vehicle of claim 15, wherein the processor is further configured to determine the axle torque request using a pedal map that includes a mathematical relation between pedal position, vehicle speed and axle torque request.
