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(54) **CONTROL OF REGENERATIVE BRAKING DURING A YAW STABILITY CONTROL EVENT**

(52) **U.S. Cl. 303/146; 303/152**

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(57) **ABSTRACT**

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The present invention is a method and system to control regenerative braking during the operation of a yaw stability control system. The method and system can use feedback control algorithms to monitor and dynamically modify regenerative and non-regenerative braking. The controller can use a simple proportional-integral-derivative feedback controller. A vehicle yaw stability control system can determine if a vehicle is experiencing an oversteer or understeer condition. The controller compares actual brake balance to a desired brake balance. The controller determines if the front axle wheels are overbraked relative to the rear axle wheels or if the rear axle wheels are overbraked relative to the front axle wheels as compared to the desired brake balance. The controller can adjust regenerative braking and non-regenerative braking levels according to the determinations.

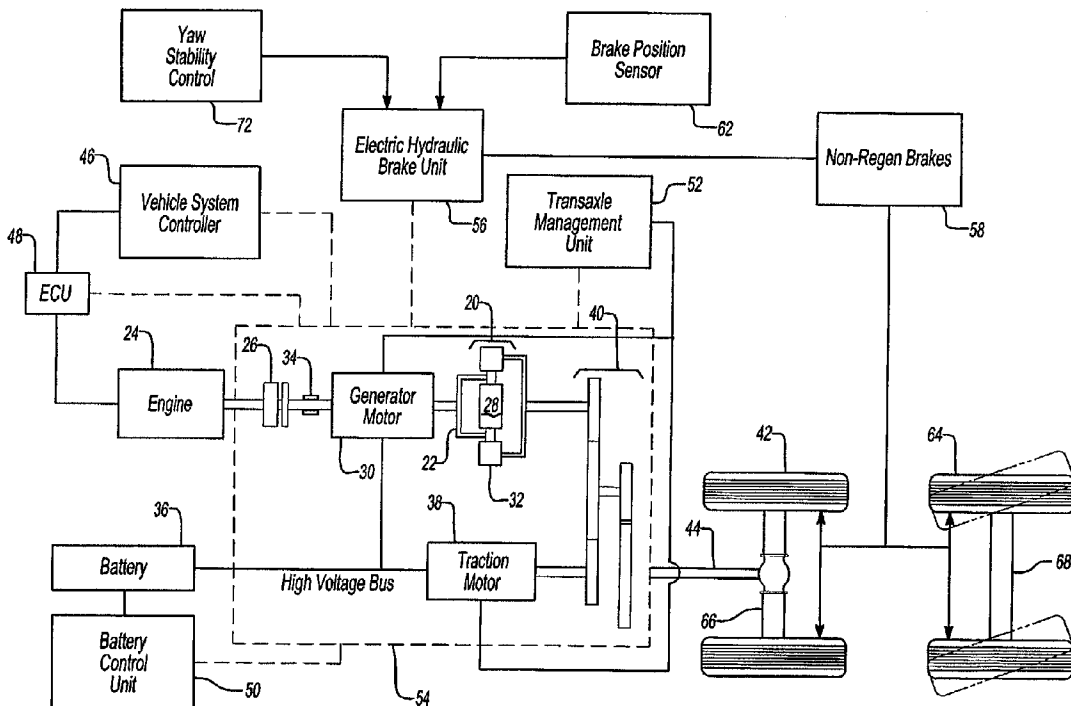
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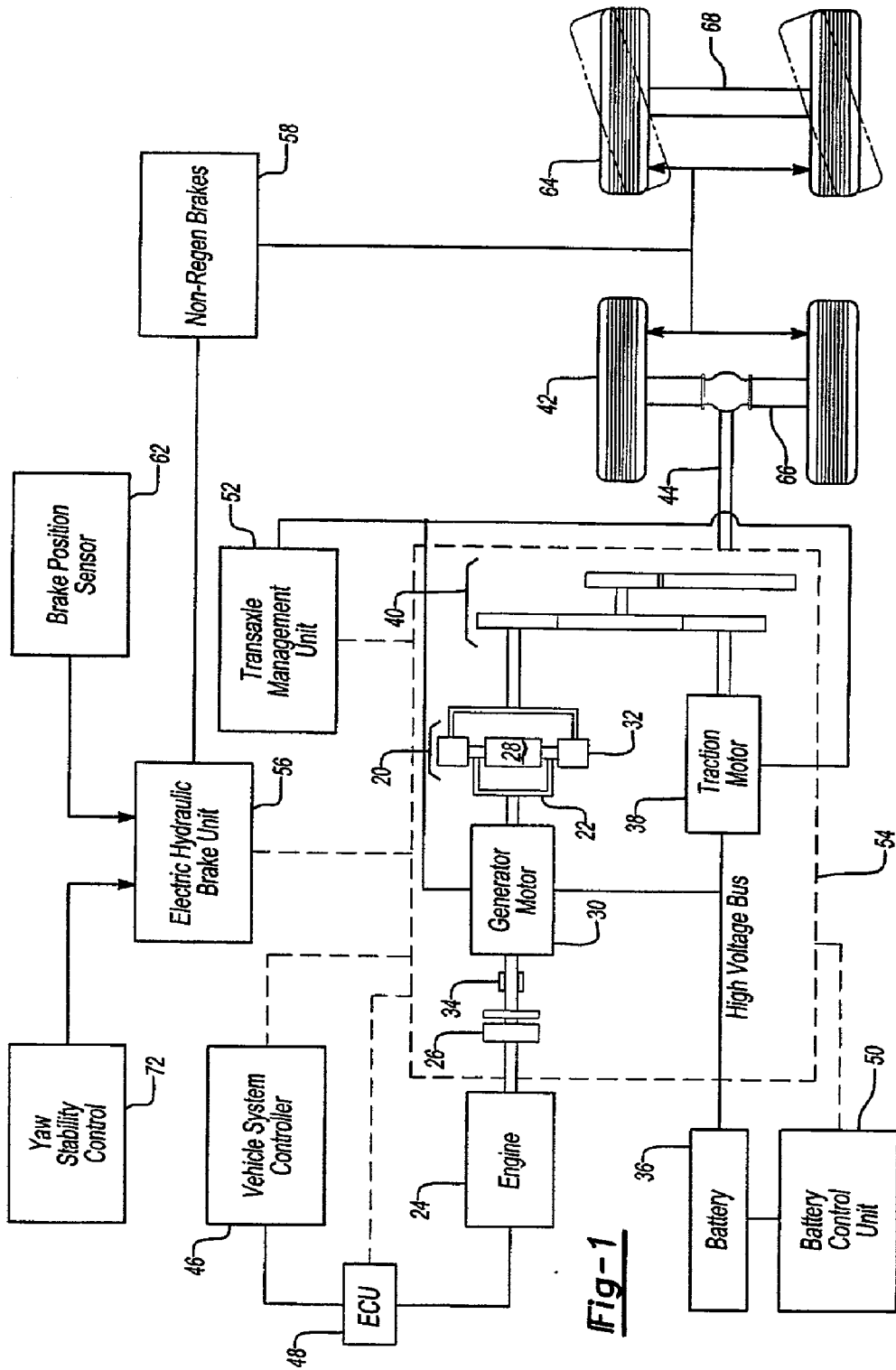


Fig-1

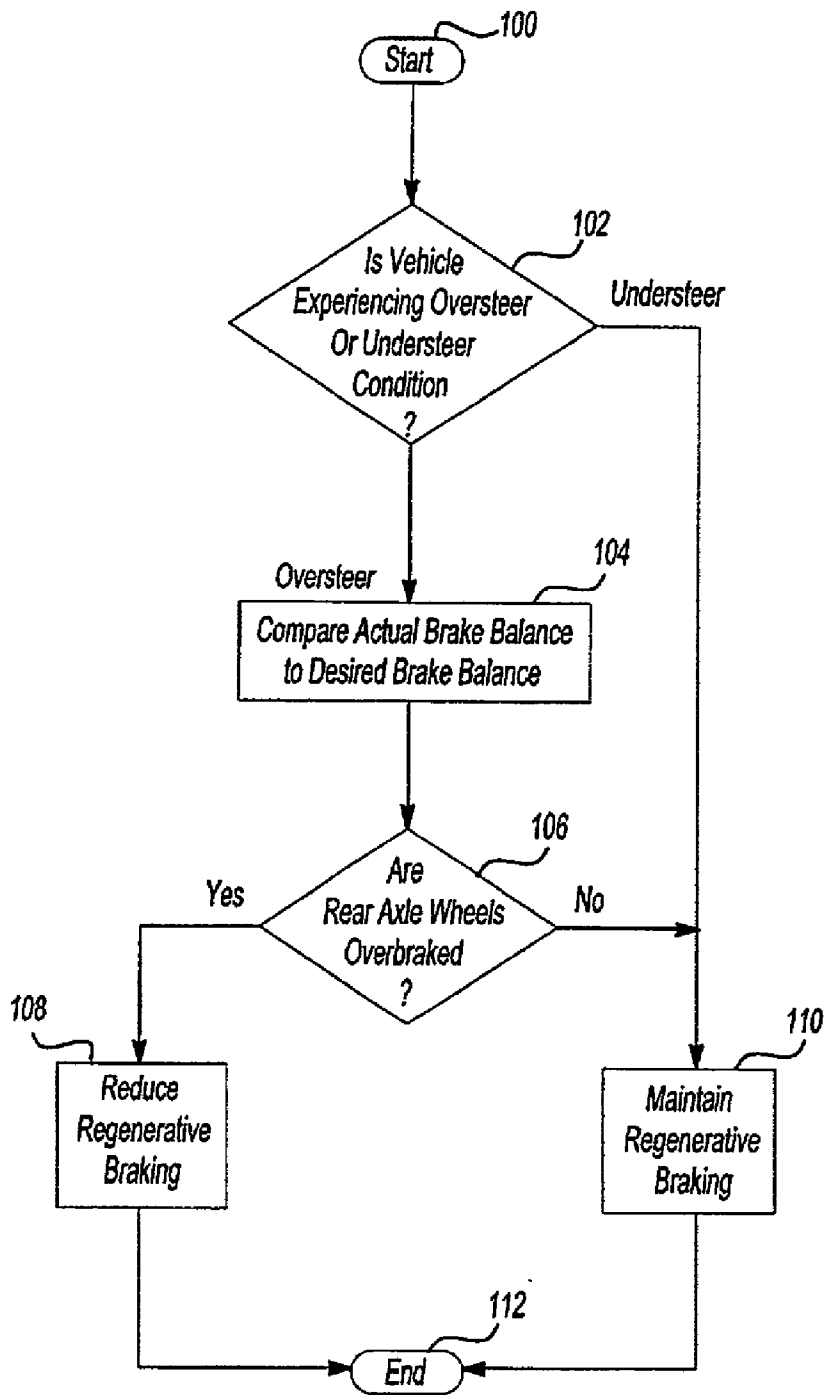
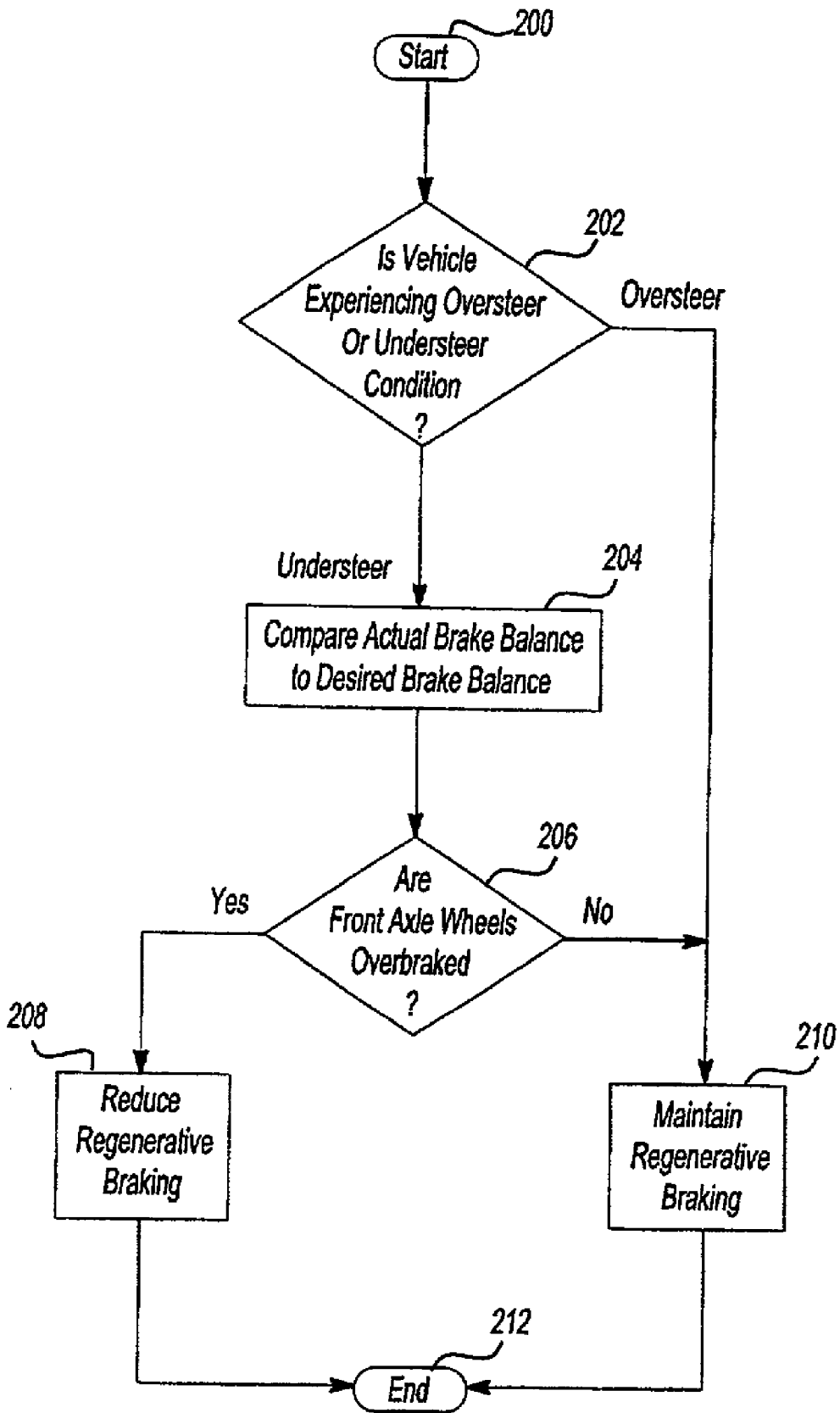


Fig-2



CONTROL OF REGENERATIVE BRAKING DURING A YAW STABILITY CONTROL EVENT

BACKGROUND OF INVENTION

[0001] The present invention relates generally to vehicle braking and controllability control systems, commonly referred to as yaw stability systems, and specifically to a braking and controllability control method and system for a vehicle with regenerative braking during the operation of a yaw stability control system.

[0002] The need to reduce fossil fuel consumption and emissions in automobiles and other vehicles predominately powered by internal combustion engines (ICEs) is well known. Vehicles powered by electric motors attempt to address these needs. Another alternative solution is to combine a smaller ICE with electric motors into one vehicle. Such vehicles combine the advantages of an ICE vehicle and an electric vehicle and are typically called hybrid electric vehicles (HEVs). See generally, U.S. Pat. No. 5,343,970 to Severinsky.

[0003] The HEV is described in a variety of configurations. Many HEV patents disclose systems where an operator is required to select between electric and internal combustion operation. In other configurations, the electric motor drives one set of wheels and the ICE drives a different set.

[0004] Other, more useful, configurations have developed. For example, a series hybrid electric vehicle (SHEV) configuration is a vehicle with an engine (most typically an ICE) connected to an electric motor called a generator. The generator, in turn, provides electricity to a battery and another motor, called a traction motor. In the SHEV, the traction motor is the sole source of wheel torque. There is no mechanical connection between the engine and the drive wheels. A parallel hybrid electrical vehicle (PHEV) configuration has an engine (most typically an ICE) and an electric motor that work together in varying degrees to provide the necessary wheel torque to drive the vehicle. Additionally, in the PHEV configuration, the motor can be used as a generator to charge the battery from the power produced by the ICE.

[0005] A parallel/series hybrid electric vehicle (PSHEV) has characteristics of both PHEV and SHEV configurations and is sometimes referred to as a "powersplit" configuration. In one of several types of PSHEV configurations, the ICE is mechanically coupled to two electric motors in a planetary gear set transaxle. A first electric motor, the generator, is connected to a sun gear. The ICE is connected to a carrier gear. A second electric motor, a traction motor, is connected to a ring (output) gear via additional gearing in a transaxle. Engine torque can power the generator to charge the battery. The generator can also contribute to the necessary wheel (output shaft) torque if the system has a one-way clutch. The traction motor is used to contribute wheel torque and to recover braking energy to charge the battery. In this configuration, the generator can selectively provide a reaction torque that may be used to control engine speed. In fact, the engine, generator motor and traction motor can provide a continuous variable transmission (CVT) effect. Further, the HEV presents an opportunity to better control engine idle speed over conventional vehicles by using the generator to control engine speed.

[0006] The desirability of combining an ICE with electric motors is clear. There is great potential for reducing vehicle fuel consumption and emissions with no appreciable loss of vehicle performance or driveability. The HEV allows the use of smaller engines, regenerative braking, electric boost, and even operating the vehicle with the engine shut down. Nevertheless, new ways must be developed to optimize the HEV's potential benefits.

[0007] One such area of HEV development is optimizing the braking and controllability system of the HEV or any other type of vehicle using regenerative braking technology. Regenerative braking (regen) captures the kinetic energy of the vehicle as it decelerates. In conventional vehicles, kinetic energy usually dissipates as heat in the vehicle's brakes or engine during deceleration. Regen converts the captured kinetic energy through a generator into electrical energy in the form of a stored charge in the vehicle's battery. This stored energy is later used to power the electric motor. Consequently, regen also reduces fuel usage and emission production. In certain vehicle configurations, the engine can be disconnected from the rest of the powertrain thereby allowing more of the kinetic energy to be converted into stored electrical energy.

[0008] On most vehicles with regenerative braking, the regenerative braking torque is applied only to, or predominantly to, the wheels of one axle. When regenerative braking is applied to only the wheels of one axle, non-regenerative braking methods may be used at the wheels of the other axles. Non-regenerative brakes are also commonly installed at the wheels of the axles having regenerative braking to supplement or back-up the regenerative braking. The desire to recover energy through regenerative braking can result in unbalanced braking torques being applied to the wheels of the different axles, that is, braking torque being applied at a different proportion than the proportionate weight on each axle. Unbalanced braking can affect vehicle controllability. These controllability effects can be in the form of either oversteer or understeer. When a disproportionate amount of regenerative braking torque is applied at the front axle, as in front wheel drive vehicles, it reduces the ability of the front wheels to steer the vehicle, a condition known as understeer. When a disproportionate amount of regenerative braking torque is applied at the rear axle, as in rear wheel drive vehicles, it reduces the lateral friction of the rear tires, a condition known as oversteer. These effects, understeer due to a disproportionate amount of regenerative braking at the front axle and oversteer due to a disproportionate amount of regenerative braking at the rear axle, can become severe on low friction surfaces such as ice and snow. The requirement for controllability on low friction surfaces typically forces regenerative braking levels to be reduced, resulting in a corresponding loss of energy recovery.

[0009] There are HEV patents to control regenerative braking functions in various driving conditions. Koga et al. (U.S. Pat. No. 6,033,041) describes a regenerative braking control system for an electric vehicle where the regenerative braking varies as a function of vehicle inclination. Okamatsu (U.S. Pat. No. 4,335,337) describes a control system for an electric powered vehicle. This invention attempts to improve tire grip performance by adjusting the frequency of the rotations of the induction motors based on the slip frequency of the vehicle without regard to regenerative braking.

[0010] Ohtsu et al. (U.S. Pat. No. 5,476,310) also attempts to improve braking performance through the cooperation of mechanical anti-lock brakes and regenerative braking. This invention regulates excessive braking force and slip with a controller using a predetermined slip ratio. Other inventions also attempt to regulate excessive slip. See Asa et al. (U.S. Pat. No. 5,654,887) and Kidston et al. (U.S. Pat. No. 5,615,933). Unfortunately, while these inventions do reduce excessive slip, they do not provide an adequate level of stability because they focus mainly on the maximization of straight line stopping.

[0011] Asanuma et al. (U.S. Pat. No. 5,318,355), describes a switchover mode from a regenerative or friction braking mode of operation. Unfortunately, this invention is susceptible to false activation of the mode switchover.

[0012] Thus, no prior art patents adequately address the desire and need to distribute brake torque between regenerative and non-regenerative braking during the operation of a yaw stability control system.

SUMMARY OF INVENTION

[0013] Accordingly, the present invention is a method and system for controlling regenerative and non-regenerative braking during operation of a yaw stability control system. The invention can provide regenerative braking during the operation of a yaw stability control system even on low friction surfaces while not significantly reducing energy recovery. The invention uses a yaw stability control system to determine if a decrease in controllability is an understeer or oversteer condition and correspondingly adjusts regenerative braking torque.

[0014] Specifically, the present invention has mechanical friction or other non-regenerative brakes known in the art connected to the wheels of at least one axle. An electric motor comprising the ability to provide regenerative braking torque is connected to the wheels of at least one axle. The present invention has a controller having the ability to receive input from a yaw stability control system, compare actual braking balance to a desired brake balance, determine if the front axle wheels or rear axle wheels are overbraked as compared to the desired brake balance, and adjust regenerative braking and non-regenerative braking levels. The controller can use a simple proportional-integral-derivative feedback controller.

[0015] In rear wheel drive vehicle configurations regenerative braking torque is applied to the rear axle wheels, and the non-regenerative brakes are connected to the front axle wheels. Non-regenerative brakes may also be connected to the rear axle wheels to supplement and/or back-up regenerative braking. The vehicle yaw stability control system will determine if the vehicle is experiencing an oversteer or understeer condition. If the vehicle is experiencing an oversteer condition and the rear axle wheels are overbraked relative to the front axle wheels as compared to a desired brake balance, regenerative braking is reduced or phased out completely. Otherwise, regenerative braking is maintained at the current level.

[0016] In front wheel drive vehicle configurations regenerative braking torque is applied to the front axle wheels, and the non-regenerative brakes are connected to the rear axle wheels. Non-regenerative brakes may also be con-

nected to the front axle wheels to supplement and/or back-up regenerative braking. The vehicle yaw stability control system will determine if the vehicle is experiencing an oversteer or understeer condition. If the vehicle is experiencing an understeer condition and the front axle wheels are overbraked relative to the rear axle wheels as compared to a desired brake balance, regenerative braking is reduced or phased out completely. Otherwise, regenerative braking is maintained at the current level.

[0017] The present invention is to provide a strategy to control regenerative braking and non-regenerative braking during the operation of a yaw stability control system.

[0018] Other objects of the present invention will become more apparent to persons having ordinary skill in the art to which the present invention pertains from the following description taken in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF DRAWINGS

[0019] The foregoing advantages and features, as well as other advantages and features, will become apparent with reference to the description and figures below, in which like numerals represent like elements and in which:

[0020] **FIG. 1** illustrates a general rear wheel drive hybrid electric vehicle (HEV) configuration.

[0021] **FIG. 2** illustrates a braking and controllability control strategy of the present invention for a rear wheel drive vehicle.

[0022] **FIG. 3** illustrates a braking and controllability control strategy of the present invention for a front wheel drive vehicle.

DETAILED DESCRIPTION

[0023] The present invention relates to electrically propelled vehicles such as electric vehicles (EVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs) that have a regenerative braking system. The present invention is a system to control regenerative braking for a vehicle during the operation of a yaw stability control system. **FIG. 1** demonstrates just one possible configuration, specifically a parallel/series hybrid electric vehicle (power-split) configuration. However, it should be understood that the present invention applies to any vehicle with regenerative braking and a yaw stability control system.

[0024] In a basic HEV, a planetary gear set **20** mechanically couples a carrier gear **22** to an engine **24** via a one-way clutch **26**. The planetary gear set **20** also mechanically couples a sun gear **28** to a generator motor **30** and a ring (output) gear **32**. The generator motor **30** also mechanically links to a generator brake **34** and is electrically linked to a battery **36**. A traction motor **38** is mechanically coupled to the ring gear **32** of the planetary gear set **20** via a second gear set **40** and is electrically linked to the battery **36**. The ring gear **32** of the planetary gear set **20** and the traction motor **38** are mechanically coupled to rear axle wheels **42** via an output shaft **44** that is mechanically coupled to a rear axle **66** having the rear axle wheels **42**. For purposes of illustration, the vehicle can also have a separate pair of front axle wheels **64** connected by a front axle **68** that are non-driven and are steerable. The front axle wheels **64** are positioned toward the

front of the vehicle and the rear axle wheels **42** are positioned toward the rear of the vehicle.

[0025] The planetary gear set **20**, splits the engine **24** output energy into a series path from the engine **24** to the generator motor **30** and a parallel path from the engine **24** to the rear axle wheels **42**. Engine **24** speed can be controlled by varying the split to the series path while maintaining the mechanical connection through the parallel path. The traction motor **38** augments the engine **24** power to the rear axle wheels **42** on the parallel path through the second gear set **40**. The traction motor **38** also provides the opportunity to use energy directly from the series path, essentially running off power created by the generator motor **30**. This reduces losses associated with converting energy into and out of chemical energy in the battery **36** and allows all engine **24** energy, minus conversion losses, to reach the rear axle wheels **42**.

[0026] A vehicle system controller (VSC) **46** controls many components in this HEV configuration by connecting to each component's controller. An engine control unit (ECU) **48** connects to the engine **24** via a hardwire interface. All vehicle controllers can be physically combined in any combination or can stand as separate units. They are described as separate units here because they each have distinct functionality. The VSC **46** communicates with the ECU **48**, as well as a battery control unit (BCU) **50** and a transaxle management unit (TMU) **52** through a communication network such as a controller area network (CAN) **54**. The BCU **50** connects to the battery **36** via a hardwire interface. The TMU **52** controls the generator motor **30** and the traction motor **38** via a hardwire interface.

[0027] Further, the VSC **46** can communicate with an electric hydraulic braking unit (EHBU) **56** through the CAN **54**. The EHBU **56** is connected to non-regenerative brakes **58** that ultimately are connected to the front axle wheels **64**. The non-regenerative brakes **58** can also be connected to the rear axle wheels **42**. The EHBU **56** can control anti-lock braking systems (ABS) (not shown), regenerative braking, traction control systems (not shown), a yaw stability control system **72**, and the non-regenerative brakes **58**. The EHBU **56** can control these systems either in response to operator input or independent of operator input. In the present invention, braking control for the rear axle wheels **42** and the front axle wheels **64** is independently available. The EHBU **56** can receive input from various vehicle systems. Specific to the present invention are inputs for a brake position sensor **62** (such as a brake pedal), and the yaw stability control system **72**.

[0028] The present invention is a method and system to control regenerative braking and non-regenerative braking during operation of the yaw stability control system for a vehicle equipped with regenerative braking, such as the configuration illustrated in FIG. 1. The invention can provide regenerative braking in the event of oversteer and understeer conditions even on low friction surfaces. The controller of the present invention can be physically located either within the VSC **46** or as a stand-alone unit, such as the EHBU **56**. The controller receives input from the yaw stability control system **72**, compares actual braking to a desired brake balance and correspondingly commands a reduction or maintenance of regenerative braking. The desired brake balance is a representation of an ideal brake

balance or a brake balance that is normally achieved with conventional non-regenerative braking.

[0029] As stated above, most vehicle configurations with regenerative braking apply braking torque to the wheels of one axle (or predominately to the wheels of one axle). When regenerative braking is applied to only the wheels of one axle, conventional non-regenerative braking methods can be used at the wheels of the other axles to balance the vehicle's overall braking torque. The non-regenerative brakes **58** may also be used at the wheels of the axle having regenerative braking to supplement and/or back-up the regenerative braking. To demonstrate this in the vehicle configuration in FIG. 1, the EHBU **56** could command regenerative braking at the rear axle wheels **42** of the rear axle **66** (i.e., a rear wheel drive configuration). The EHBU **56** could concurrently command an application of the conventional non-regenerative brakes **58** to the front axle wheels **64** of the front axle **68**. Unfortunately, in this example optimal regenerative energy is not realized because any braking torque using the non-regenerative brakes **58** results in kinetic energy wasted as heat. Ideally, maximum energy recovery would occur with complete regenerative braking.

[0030] The challenge of maximum energy recovery through regenerative braking is that unbalanced braking torques between the front axle wheels **64** and the rear axle wheels **42** can affect vehicle controllability. For example, in a front wheel drive vehicle configuration (not shown), if a disproportionate amount of braking torque is applied to the front axle wheels **64** of the front axle **68** in an attempt to maximize energy recovery (e.g., less non-regenerative braking force is applied to the rear axle wheels **42** than the desired brake balance would call for), the ability to steer the front axle wheels **64** is reduced (understeer). In a rear wheel drive vehicle configuration, when a disproportionate amount of braking torque is applied at the rear axle wheels **42** of the rear axle **66** in an attempt to maximize energy recovery (e.g., less non-regenerative braking force is applied to the front axle wheels **64** than the desired brake balance would call for), the lateral friction of the rear axle wheels **42** is reduced (oversteer). These controllability conditions can become more severe on low friction surfaces such as ice and snow.

[0031] FIG. 2 illustrates a braking and controllability control strategy of the present invention for a rear wheel drive vehicle. In rear wheel drive vehicle configurations, regenerative braking torque is applied to the rear axle wheels **42**, and the non-regenerative brakes **58** are connected to the front axle wheels **64**. The non-regenerative brakes **58** may also be connected to the rear axle wheels **42** to supplement and/or back-up regenerative braking. The strategy starts at step **100**. At step **102** the yaw stability control system **72** determines if the vehicle is experiencing an oversteer or understeer condition. If the vehicle is experiencing the oversteer condition, the strategy proceeds to step **104**. If the vehicle is experiencing the understeer condition, the strategy proceeds to step **110** where regenerative braking is commanded to be maintained at the current level. Following step **110**, the strategy ends at step **112**.

[0032] At step **104** the actual brake balance is compared to the desired brake balance and the strategy proceeds to step **106**. At step **106** the strategy determines if the rear axle wheels **42** are overbraked relative to the front axle wheels **64** as compared to the desired brake balance. If the rear axle

wheels **42** are overbraked, the strategy proceeds to step **108**. Otherwise, the strategy proceeds to step **110**.

[**0033**] At step **108**, the strategy commands a reduction in regenerative braking until the desired brake balance is achieved or regenerative braking is phased out completely. When regenerative braking is reduced or phased out, the strategy switches to non-regenerative braking that is distributed to achieve the desired brake balance. Following step **108**, the strategy ends at step **112**.

[**0034**] Returning to step **106**, if the strategy determines the rear axle wheels **42** are not overbraked relative to the front axle wheels **64** as compared to the desired brake balance, the strategy proceeds to step **110**. Following step **110**, the strategy ends at step **112**.

[**0035**] **FIG. 3** illustrates the braking and controllability control strategy of the present invention for a front wheel drive vehicle. In front wheel drive vehicle configurations, regenerative braking torque is applied to the front axle wheels **64** and non-regenerative brakes **58** are connected to the rear axle wheels **42**. The non-regenerative brakes **58** may also be connected to the front axle wheels **64** to supplement and/or back-up regenerative braking. The strategy starts at step **200**. At step **202** the yaw stability control system **72** determines if the vehicle is experiencing the oversteer or understeer condition. If the vehicle is experiencing the oversteer condition, the strategy proceeds to step **210** where regenerative braking is commanded to be maintained at the current level. Following step **210**, the strategy ends at step **212**. If the vehicle is experiencing the understeer condition, the strategy proceeds to step **204**.

[**0036**] At step **204** the actual brake balance is compared to the desired brake balance and the strategy proceeds to step **206**. At step **206** the strategy determines if the front axle wheels **64** are overbraked relative to the rear axle wheels **42** as compared to the desired brake balance. If the front axle wheels **64** are overbraked, the strategy proceeds to step **208**. Otherwise, the strategy proceeds to step **210**.

[**0037**] At step **208**, the strategy commands a reduction in regenerative braking until the desired brake balance is achieved or regenerative braking is phased out completely. When regenerative braking is reduced or phased out, the strategy switches to non-regenerative braking that is distributed to achieve the desired brake balance. Following step **208**, the strategy ends at step **212**.

[**0038**] Returning to step **206**, if the strategy determines the front axle wheels **64** are not overbraked as compared to the desired brake balance, the strategy proceeds to step **210**. Following step **210**, the strategy ends at step **212**.

[**0039**] When regenerative braking is reduced because of a yaw stability control event, regenerative braking should only be reduced by the amount necessary to achieve the desired brake balance. By reducing regenerative braking only by the amount necessary to achieve the desired brake balance, energy recovery is maximized while vehicle controllability is enhanced.

[**0040**] When regenerative braking is reduced or phased out because of a yaw stability control event, regenerative braking should be reduced gradually over a period of time that provides a quick return to balanced braking. This time period should be long enough to allow the switch between

regenerative and non-regenerative braking to be smooth. During the switch, the total braking torque should remain the same. To keep total braking torque the same throughout the switch, non-regenerative braking should be increased or phased in at the same rate regenerative braking is reduced or phased out. A typical time period for such a switch may be between 50 msec and 1 sec.

[**0041**] In an alternate embodiment of the present invention, the strategy can switch from regenerative braking to non-regenerative braking while maintaining the brake balance that resulted from regenerative braking. For example, in the situations described above when the controller would command regenerative braking to be maintained at the current level, as illustrated at **FIG. 2, 110** and **FIG. 3, 210**, the strategy can switch, in whole or in part, from regenerative braking to non-regenerative brakes **58** at the axle having regenerative braking with the same actual brake torque. In these situations, the actual brake balance is maintained and the non-regenerative brakes **58** replace, in whole or in part, regenerative braking at the wheels of the axle having regenerative braking.

[**0042**] In this alternate embodiment, energy recovery is forsaken for the few moments of the yaw stability control event in favor of using non-regenerative brakes **58**.

[**0043**] The present invention can use feedback control algorithms to monitor and dynamically modify regenerative and non-regenerative braking. For example, a simple proportional-integral-derivative feedback controller can be used.

[**0044**] The above-described embodiments of the invention are provided purely for purposes of example. Many other variations, modifications, and applications of the invention may be made. Variations could include, but are not limited to, applying the invention to all wheel drive vehicles or four wheel drive vehicles. In the case of four wheel drive or all wheel drive vehicles, the regenerative braking may be distributed to more than one axle. The principles described above, of when to maintain or reduce regenerative braking, would still apply.

[**0045**] Additionally, those skilled in the art will understand that the yaw stability control system **72** can give additional braking commands that can be superimposed on the braking commands of the present invention.

1. A system to control braking for a vehicle during a yaw stability control event, comprising:

a yaw stability control system to determine if the vehicle is experiencing an understeer or oversteer condition;

non-regenerative brakes connected to wheels of at least one axle;

regenerative braking is applied to the wheels of at least one axle; and

a controller comprising an ability to receive input from the yaw stability control system, compare actual brake balance to a desired brake balance, determine if front axle wheels or rear axle wheels are overbraked as compared to the desired brake balance, and adjust regenerative braking and non-regenerative braking levels.

2. The system of claim 1, wherein the controller is a simple proportional-integral-derivative feedback controller.

3. The system of claim 1, wherein the controller adjusts regenerative braking and non-regenerative braking levels over a period of time that provides a quick return to balanced braking and allows a switch between regenerative and non-regenerative braking to be smooth.

4. The system of claim 1, wherein the controller adjusts regenerative braking and non-regenerative braking levels over a period of time between 50 msec and 1 sec.

5. The system of claim 1, wherein:

the non-regenerative brakes are connected to front axle wheels; and

regenerative braking is applied to rear axle wheels.

6. The system of claim 5, wherein:

the controller reduces regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are overbraked relative to the front axle wheels.

7. The system of claim 5, wherein:

the controller maintains regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition.

8. The system of claim 5, wherein:

the controller maintains regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are not overbraked relative to the front axle wheels.

9. The system of claim 5, wherein:

the non-regenerative brakes are also connected to the rear axle wheels; and

the controller switches from regenerative braking to non-regenerative braking at the rear axle wheels when the yaw stability control system determines the vehicle is experiencing said understeer condition.

10. The system of claim 5 wherein:

the non-regenerative brakes are also connected to the rear axle wheels; and

the controller switches from regenerative braking to non-regenerative braking at the rear axle wheels when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are not overbraked relative to the front axle wheels.

11. The system of claim 1, wherein:

the non-regenerative brakes are connected to rear axle wheels; and

regenerative braking is applied to front axle wheels.

12. The system of claim 11, wherein:

the controller reduces regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are overbraked relative to the rear axle wheels.

13. The system of claim 11, wherein:

the controller maintains regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition.

14. The system of claim 11, wherein:

the controller maintains regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are not overbraked relative to the rear axle wheels.

15. The system of claim 11, wherein:

the non-regenerative brakes are also connected to the front axle wheels; and

the controller switches from regenerative braking to non-regenerative braking at the front axle wheels when the yaw stability control system determines the vehicle is experiencing said oversteer condition.

16. The system of claim 11, wherein:

the non-regenerative brakes are also connected to the front axle wheels; and

the controller switches from regenerative braking to non-regenerative braking at the front axle wheels when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are not overbraked relative to the rear axle wheels.

17. A method to control regenerative braking for a vehicle having a yaw stability control system, an ability to provide regenerative braking torque to wheels of at least one axle, non-regenerative brakes connected to the wheels of at least one axle, the method comprising the steps of:

determining in the yaw stability control system if the vehicle is experiencing an understeer or oversteer condition; and

controlling the vehicle by receiving input from the yaw stability control system, comparing actual brake balance to a desired brake balance, determining if front axle wheels or rear axle wheels are overbraked as compared to the desired brake balance, and adjusting regenerative braking and non-regenerative braking levels.

18. The method of claim 17, wherein the step of controlling the vehicle comprises using a simple proportional-integral-derivative feedback controller.

19. The method of claim 17, wherein the step of adjusting regenerative braking and non-regenerative braking levels is accomplished over a period of time that provides a quick return to balanced braking and allows a switch between regenerative braking and non-regenerative braking to be smooth.

20. The method of claim 17, wherein the step of adjusting regenerative braking and non-regenerative braking levels is accomplished over a period of time between 50 msec and 1 sec.

21. The method of claim 17, wherein:

regenerative braking is applied to the rear axle wheels; and

the non-regenerative brakes are connected to the front axle wheels.

22. The method of claim 21, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

reducing regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are overbraked relative to the front axle wheels.

23. The method of claim 21, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

maintaining regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition.

24. The method of claim 21, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

maintaining regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are not overbraked relative to the front axle wheels.

25. The method of claim 21, wherein:

the non-regenerative brakes are also connected to the rear axle wheels; and

the step of adjusting regenerative braking and non-regenerative braking levels comprises switching from regenerative braking to non-regenerative braking at the rear axle wheels when the yaw stability control system determines the vehicle is experiencing said understeer condition.

26. The method of claim 21, wherein:

the non-regenerative brakes are also connected to the rear axle wheels; and

the step of adjusting regenerative braking and non-regenerative braking levels comprises switching from regenerative braking to non-regenerative braking at the rear axle wheels when the yaw stability control system determines the vehicle is experiencing said oversteer condition and the rear axle wheels are not overbraked relative to the front axle wheels.

27. The method of claim 17, wherein:

regenerative braking is applied to the front axle wheels; and

the non-regenerative brakes are connected to the rear axle wheels.

28. The method of claim 27, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

reducing regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are overbraked relative to the rear axle wheels.

29. The method of claim 27, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

maintaining regenerative braking when the yaw stability control system determines the vehicle is experiencing said oversteer condition.

30. The method of claim 27, wherein the step of adjusting regenerative braking and non-regenerative braking levels comprises the step of:

maintaining regenerative braking when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are not overbraked relative to the rear axle wheels.

31. The method of claim 27, wherein:

the non-regenerative brakes are also connected to the front axle wheels; and

the step of adjusting regenerative braking and non-regenerative braking levels comprises switching from regenerative braking to non-regenerative braking at the front axle wheels when the yaw stability control system determines the vehicle is experiencing said oversteer condition.

32. The method of claim 27, wherein:

the non-regenerative brakes are also connected to the front axle wheels; and

the step of adjusting regenerative braking and non-regenerative braking levels comprises switching from regenerative braking to non-regenerative braking at the front axle wheels when the yaw stability control system determines the vehicle is experiencing said understeer condition and the front axle wheels are not overbraked relative to the rear axle wheels.

33. An article of manufacture to control regenerative braking for a vehicle comprising:

a yaw stability control system;

an ability to provide regenerative braking torque to wheels of at least one axle;

non-regenerative brakes connected to the wheels of at least one axle;

a controller; and

a control system embodied within the controller for directing the controller to control regenerative braking and non-regenerative braking during operation of the yaw stability control system.

34. An automotive vehicle, comprising:

a yaw stability control system;

an ability to provide regenerative braking torque to wheels of at least one axle;

non-regenerative brakes connected to the wheels of at least one axle;

a controller; and

a control system embodied within the controller for directing the controller to control regenerative braking and non-regenerative braking during operation of the yaw stability control system.

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