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(54) MODEL-BASED CONTROL FOR TORQUE BIASING SYSTEM

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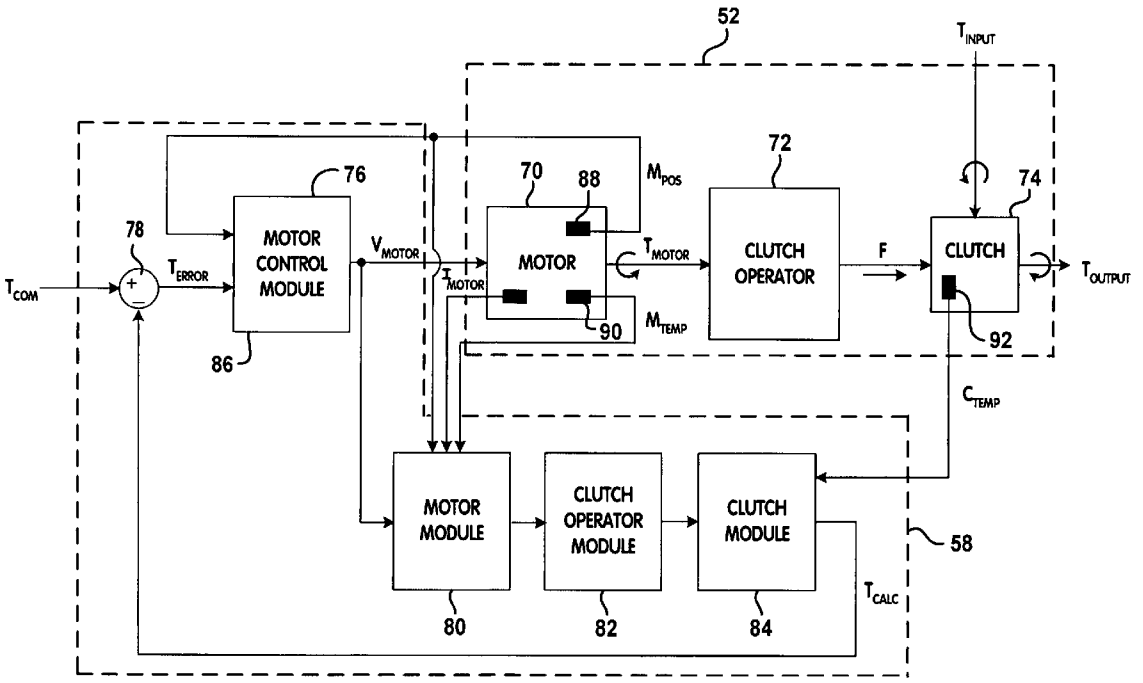
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(57) **ABSTRACT**

A power transmission device equipped with a torque biasing system and control system for controlling the torque biasing system is operable to determine a torque command and calculate a torque error based on the torque command and a model-based torque. A control signal is generated based on the torque error and the torque biasing system is operated based on the control signal.



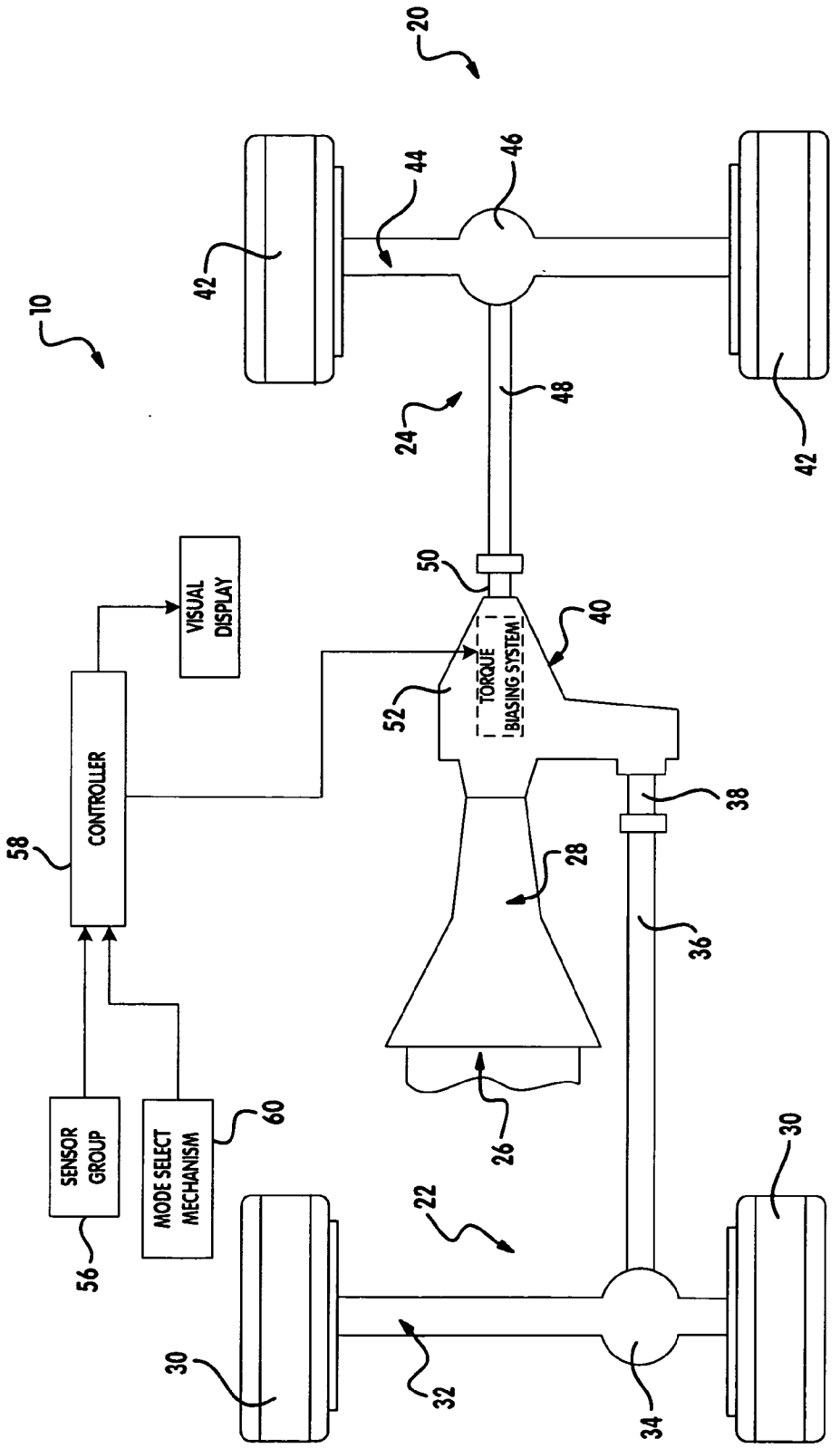

20
10
42
44
46
48
24
42
50
40
52
TORQUE BIASING SYSTEM
VISUAL DISPLAY
CONTROLLER
58
38
28
36
26
SENSOR GROUP
MODE SELECT MECHANISM
60
56
22
30
30
32
34

FIG. 1

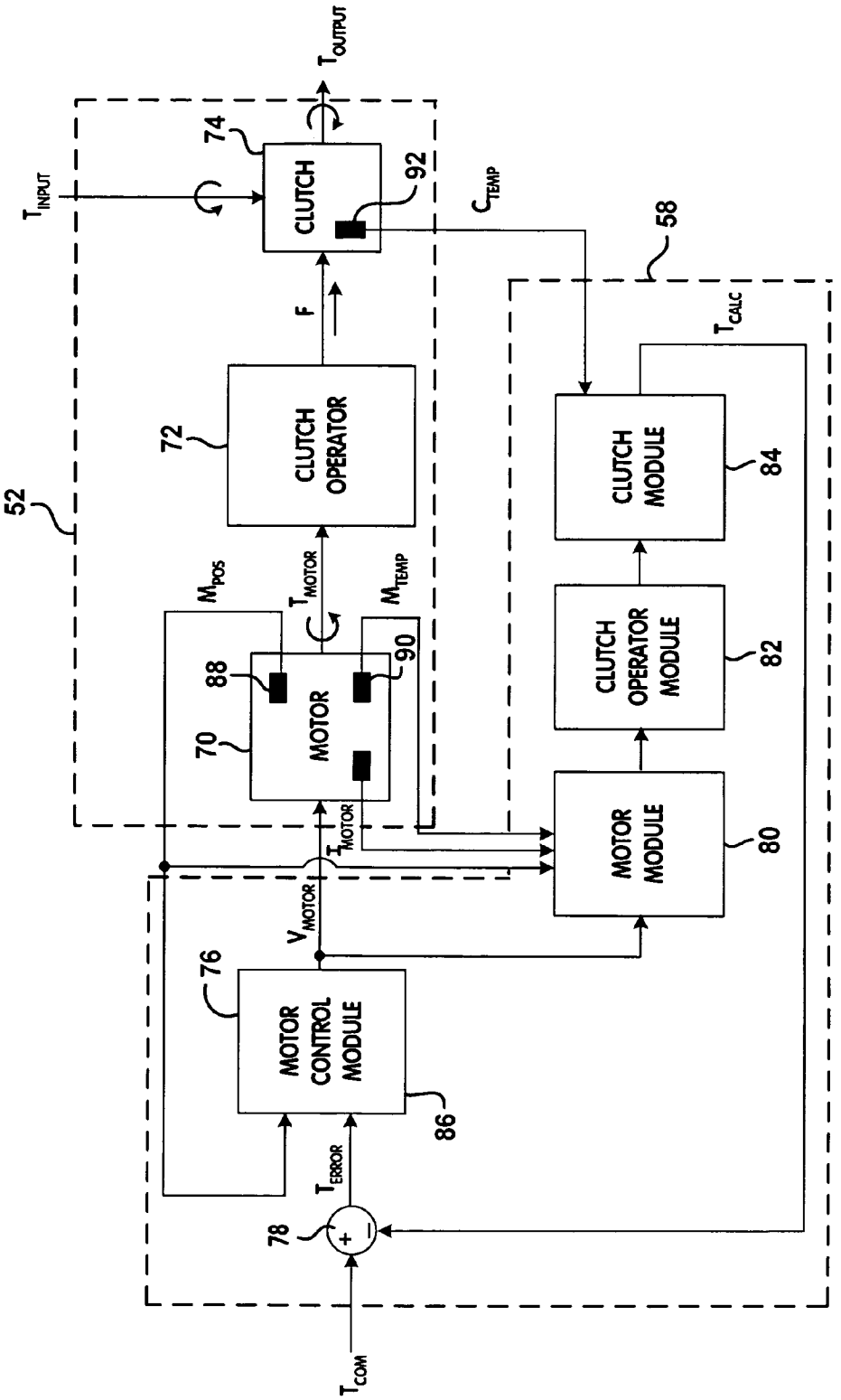

T_OUTPUT
74
CLUTCH
92
T_INPUT
C_TEMP
58
F
T_CALC
72
CLUTCH OPERATOR
CLUTCH MODULE
84
52
M_POS
T_MOTOR
M_TEMP
90
88
CLUTCH OPERATOR MODULE
82
70
MOTOR
I_MOTOR
MOTOR MODULE
80
V_MOTOR
76
MOTOR CONTROL MODULE
86
T_ERROR
78
T_COM

FIG. 2

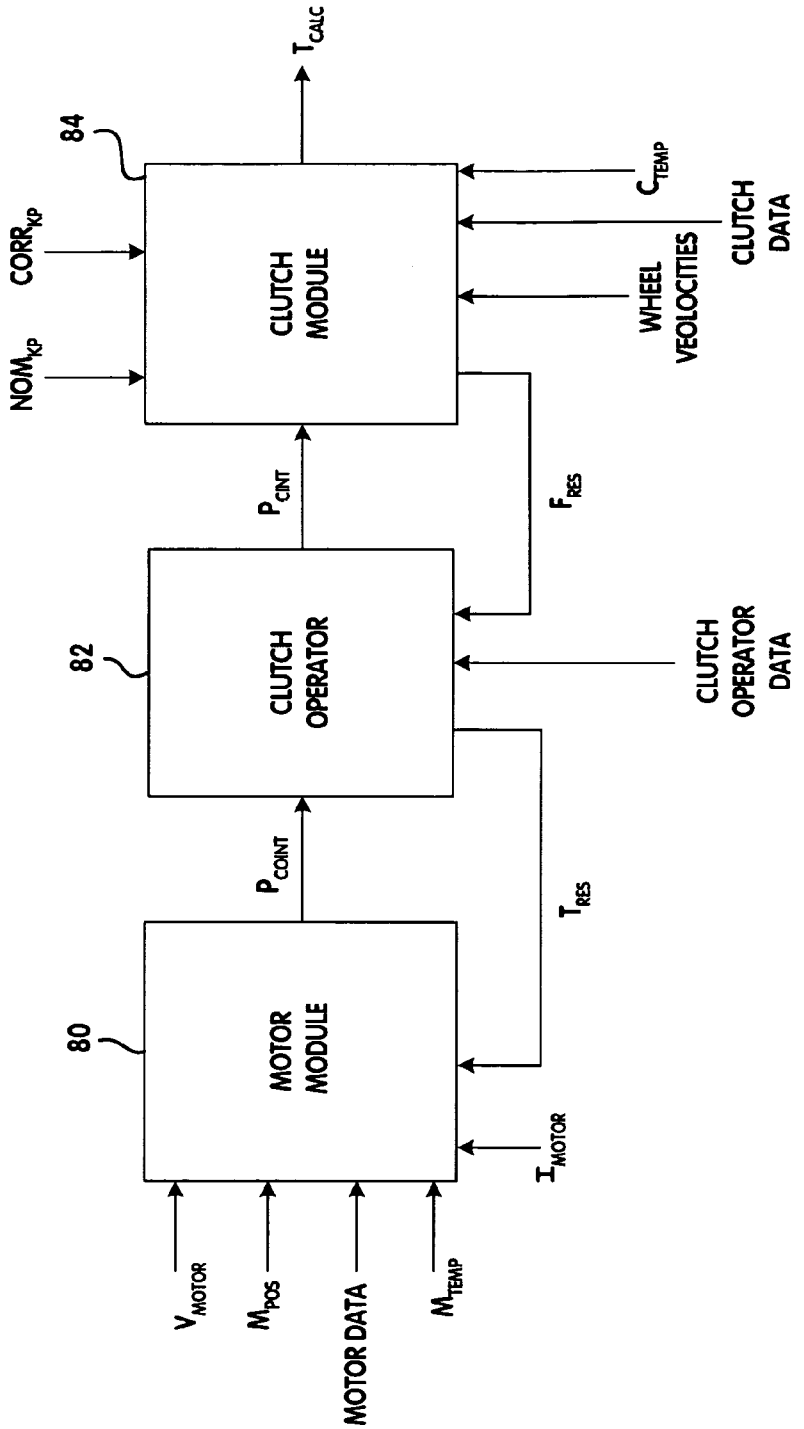

T_CALC
84
CLUTCH MODULE
CORR_KP
NOM_KP
C_TEMP
CLUTCH DATA
WHEEL VEOLOCITIES
P_CINT
F_RES
82
CLUTCH OPERATOR
CLUTCH OPERATOR DATA
P_COINT
T_RES
80
MOTOR MODULE
I_MOTOR
V_MOTOR
M_POS
MOTOR DATA
M_TEMP

FIG. 3

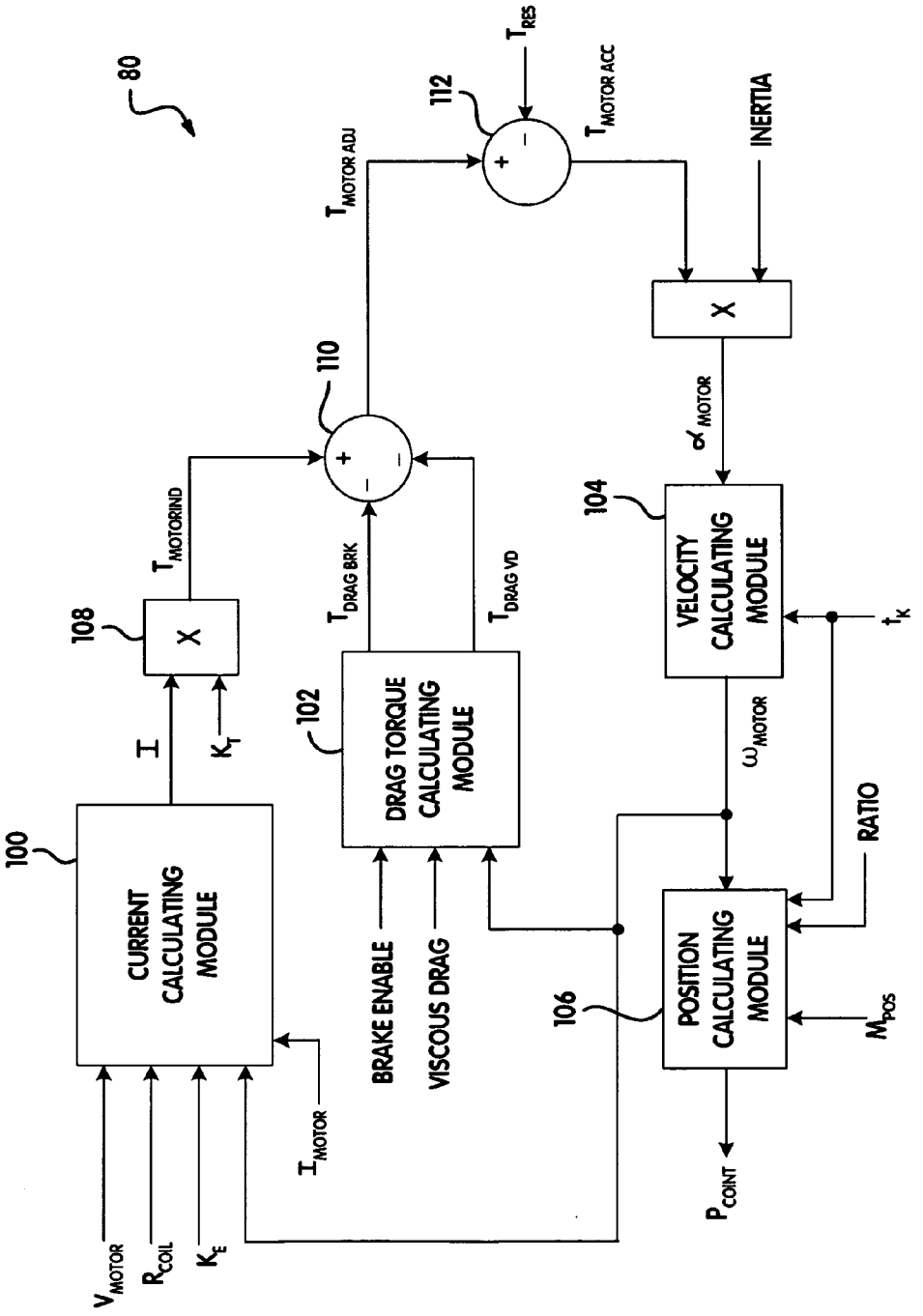

80
112
T_{RES}
$T_{MOTOR\ ACC}$
INERTIA
$T_{MOTOR\ ADJ}$
X
110
α_{MOTOR}
104
VELOCITY CALCULATING MODULE
t_K
$T_{MOTORIND}$
$T_{DRAG\ BRK}$
$T_{DRAG\ VD}$
108
X
102
DRAG TORQUE CALCULATING MODULE
ω_{MOTOR}
I
K_T
100
CURRENT CALCULATING MODULE
RATIO
BRAKE ENABLE
VISCOUS DRAG
106
POSITION CALCULATING MODULE
M_{POS}
I_{MOTOR}
P_{COINT}
V_{MOTOR}
R_{COIL}
K_E

FIG. 4

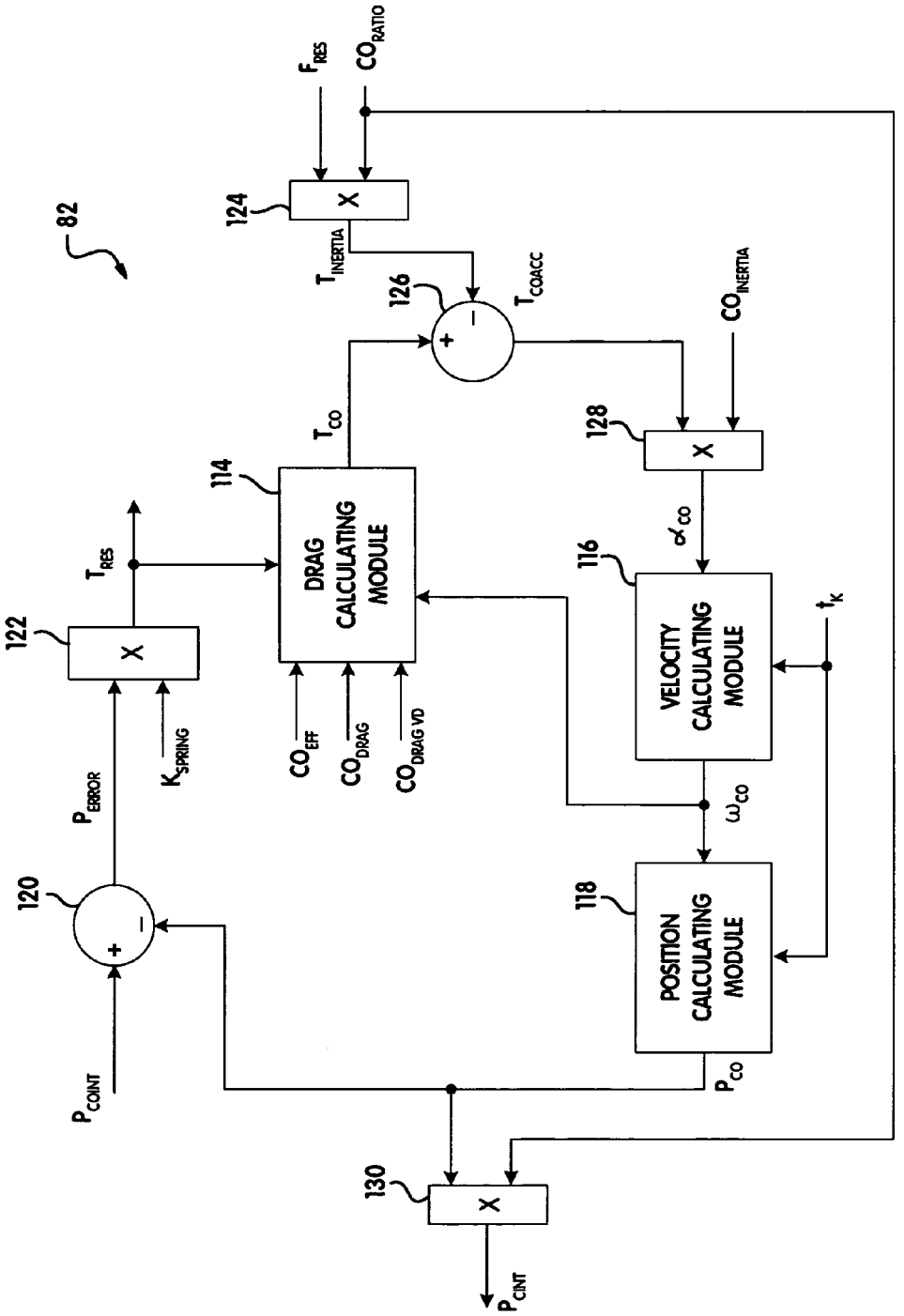

82
124
X
F_{RES}
CO_{RATIO}
$T_{INERTIA}$
126
T_{COACC}
$CO_{INERTIA}$
T_{CO}
128
X
114
DRAG CALCULATING MODULE
α_{CO}
116
VELOCITY CALCULATING MODULE
t_K
T_{RES}
122
X
CO_{EFF}
CO_{DRAG}
$CO_{DRAG\ VD}$
K_{SPRING}
P_{ERROR}
ω_{CO}
120
118
POSITION CALCULATING MODULE
P_{COINT}
P_{CO}
130
X
P_{CINT}

FIG. 5

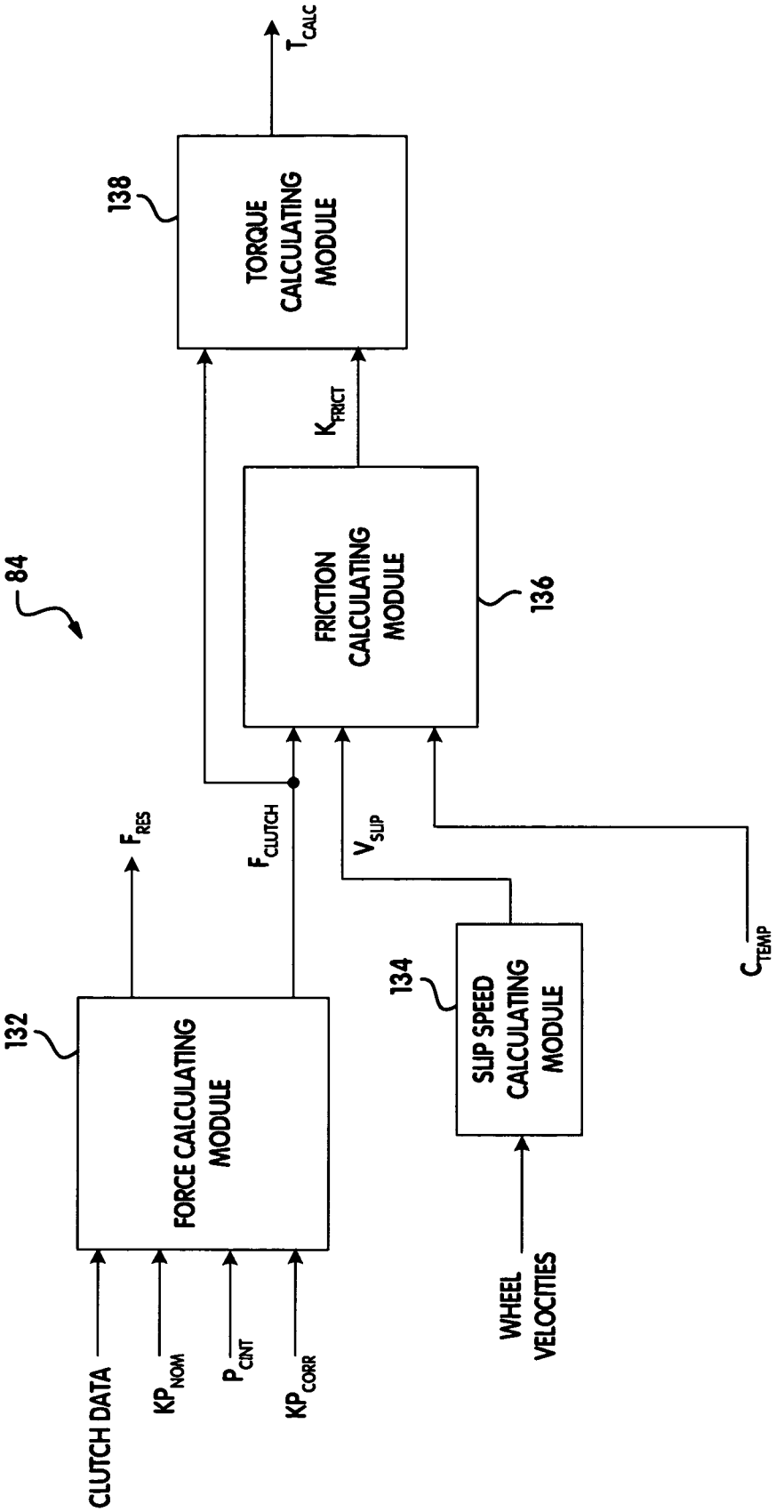

84
138
TORQUE CALCULATING MODULE
T_{CALC}
136
FRICTION CALCULATING MODULE
K_{FRICT}
132
FORCE CALCULATING MODULE
F_{RES}
F_{CLUTCH}
134
SLIP SPEED CALCULATING MODULE
V_{SLIP}
C_{TEMP}
CLUTCH DATA
KP_{NOM}
P_{CINT}
KP_{CORR}
WHEEL VELOCITIES

FIG. 6

MODEL-BASED CONTROL FOR TORQUE BIASING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 10/827,550 filed Apr. 19, 2004.

FIELD OF THE INVENTION

[0002] The present invention relates to torque biasing systems, and more particularly to model-based control of a torque biasing system.

BACKGROUND OF THE INVENTION

[0003] Torque biasing systems can be implemented in vehicle components including, but not limited to, a transfer case, a power take-off unit (PTU) and an axle. Torque biasing systems regulate torque transfer between an input and an output. More specifically, a clutch pack is operably disposed between the input and the output. The degree of engagement of the clutch pack is varied to regulate the amount of torque transferred from the input to the output. For example, when the clutch pack is disengaged, there is no torque transfer from the input to the output. When the clutch pack is fully engaged or locked, all of the torque is transferred from the input to the output. When partially engaged, a corresponding portion of the torque is transferred from the input to the output.

[0004] The degree of clutch pack engagement is adjusted by a linear force that is imparted on the clutch pack via an actuator system. Traditional actuator systems include an electric motor and a clutch operator mechanism. The clutch operator mechanism converts the torque generated by the electric motor into the linear force, which can be amplified prior to being imparted on the clutch pack. The electric motor is controlled based on a control signal generated by a control system.

[0005] Conventional control systems use closed-loop control to regulate a specified system parameter. When the specified system parameter has an accurate means of feedback, such as is the case with direct sensing, the overall system accuracy is sufficient. In the case where the specified system parameter is not directly measurable, system accuracy is difficult to achieve.

[0006] Torque biasing systems are typically controlled based on a parameter other than torque, because torque is not easily measurable and torque sensors are not readily available. Torque sensors, however, would not be a total solution because the actual torque generated by a vehicle system is often much slower than is required by the biasing device. As a result, conventional torque biasing systems are not controlled as accurately as is desired.

SUMMARY OF THE INVENTION

[0007] Accordingly, the present invention provides a method of controlling a torque biasing system. The method includes determining a torque command, calculating a torque error based on the torque command and a model-based torque. A control signal is generated based on the torque error and the torque biasing system is operated based on the control signal.

[0008] In one feature, the method further includes processing a previous control signal through a torque biasing system model to generate the model-based torque. The torque biasing system model includes a motor model, a clutch operator model and a clutch model. The control signal is processed through the motor model to generate a clutch operator interconnection value. The clutch operator interconnection value is generated based on a resistance torque, a motor position signal and motor data.

[0009] In still another feature, the method further includes calculating the resistance torque using the clutch operator model. An interconnection position value is processed through the clutch operator model to generate a clutch interconnection value. The clutch interconnection value is generated based on a resistance force and clutch operator data. The resistance force is calculated using the clutch model.

[0010] In yet another feature, the method further includes processing a clutch interconnection value through the clutch model to generate the model-based torque.

[0011] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0013] **FIG. 1** is a schematic illustration of a vehicle including a transfer case that incorporates an exemplary torque biasing system;

[0014] **FIG. 2** is a logic diagram illustrating a model-based control system according to the present invention;

[0015] **FIG. 3** is a logic diagram illustrating a torque biasing system model according to the present invention;

[0016] **FIG. 4** is a logic diagram illustrating a motor module according to the present invention;

[0017] **FIG. 5** is a logic diagram illustrating a clutch operator module according to the present invention; and

[0018] **FIG. 6** is a logic diagram illustrating a clutch module according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. As used herein, the term module refers to an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that execute one or more software or firmware programs, a combinational logic circuit, or other suitable components that provide the described functionality.

[0020] Referring now to **FIG. 1**, a four-wheel drive vehicle **10** is illustrated. The vehicle includes a front drive line **22**, a rear drive line **24**, and a power source, such as an engine **26** (partially shown), which provides drive torque to the front and rear drive lines through a transmission **28**. The transmission **28** may be either a manual or automatic shifting type. The front drive line **22** includes a pair of front wheels **30** connected to opposite ends of a front axle assembly **32** having a front differential **34**. The front differential **34** is coupled to one end of a front prop shaft **36**, the opposite end of which is coupled to a front output shaft **38** of a transfer case **40**. Similarly, the rear drive line **24** includes a pair of rear wheels **42** connected to opposite ends of a rear axle assembly **44** having a rear differential **46**. The rear differential **46** is coupled to one end of a rear prop shaft **48**, the opposite end of which is coupled to a rear output shaft **50** of the transfer case **40**. The transfer case **40** is equipped with an electronically-controlled torque biasing system **52** that is operable to control the magnitude of speed differentiation and torque distribution between the output shafts **38** and **50**.

[0021] Adaptive actuation of the torque biasing system **52** is controlled by a control system that includes a group of sensors **56** for monitoring specific dynamic and operational characteristics of the vehicle **10** and generating sensor signals indicative thereof, and a controller **58** for generating control signals in response to the sensor input signals. Moreover, the controller **58** is adapted to control the actuated condition of torque biasing system **52** by generating digital control signals based on both the sensor input signals and torque biasing system model of the present invention.

[0022] A mode select mechanism **60** enables a vehicle operator to select one of the available drive modes. In particular, the controller **58** controls the torque biasing system **52** in response to a mode signal sent to the controller **58** from mode select mechanism **60**. The mode signal indicates the particular drive mode selected. When an "adaptive" four-wheel drive mode is selected, the controller **58** operates to continuously monitor and automatically regulate the actuated condition of torque biasing system **52** between its non-actuated and fully actuated limits, thereby varying the magnitude of speed differentiation and torque distribution between output shafts **38** and **50**. When the mode signal indicates that a "locked" four-wheel drive mode has been selected, the torque biasing system **52** is fully actuated, whereby non-differentiated power is delivered to output shafts **38** and **50**. The locked four-wheel drive mode is provided to permit improved traction when the vehicle is operated off road or over severe road conditions.

[0023] Referring now to **FIG. 2**, a schematic illustration of the torque biasing system **52** is shown. The torque biasing system **52** includes a motor **70**, a clutch operator mechanism **72** and a clutch-pack **74**. It is anticipated that the clutch operator mechanism includes a driven torque/force conversion device with an amplifier mechanism. Anticipated drivers include motors or solenoids. Anticipated torque/force conversion devices include cam/follower devices, dual cam plate devices and scissor plates and anticipated amplifier mechanisms include levers and ball ramps. An input torque (T_{INPUT}) is transferred through the clutch-pack **74** to provide an output torque (T_{OUTPUT}). The motor **70** is operated based on a control signal to manipulate the clutch operator mechanism **72**. The gear reduction/shift lever system **72** imparts a linear force on the clutch-pack **74** that regulates engagement of the clutch-pack **74**. T_{OUTPUT} is based on the degree of clutch-engagement. The controller **58** generates the control signal as discussed in detail below.

[0024] Referring now to **FIG. 2**, the model-based control of the present invention will be described in detail. A torque command (T_{COM}) is generated based on vehicle inputs. T_{COM} is the amount of torque that is to be transferred through the torque biasing system **52** and is a running calculation based on wheel speeds, yaw rate, throttle and the like. The wheel speeds, yaw rate and throttle signals are generated by the sensor group **56**. A summer **78** generates a torque error (T_{ERROR}) as the difference between T_{COM} and a model-based torque (T_{CALC}). The model-based control is implemented via a motor module **80**, a clutch operator module **82** and a clutch module **84** as described in further detail below. More particularly, the motor module **80** is based on a motor model, the clutch operator module **82** is based on a shift system model and the clutch module **84** is based on a clutch model.

[0025] A motor control module **86** generates a motor voltage (V_{MOTOR}) based on TERROR and a motor position signal (M_{POS}). The motor control module **86** is preferably a proportional, integral, derivative (PID) control module of a type known in the art. The motor **70** operates based on V_{MOTOR} and includes a position sensor **88** and a temperature sensor **90**. The position sensor **88** generates M_{POS}, which indicates the rotational position of the motor armature (not shown). The temperature sensor **90** generates a motor temperature signal (M_{TEMP}). The motor **70** generates a torque (T_{MOTOR}) that drives the shift system **72**.

[0026] The shift system **72** generates a linear force (F) that is imparted on the clutch pack **74**. F controls the engagement of the clutch pack **74**. More particularly, as F increases, clutch slip is decreased until lock-up is achieved. During clutch slip, the input torque (T_{INPUT}) is greater than the output torque (T_{OUTPUT}). At clutch lock-up, T_{INPUT} is equal to T_{OUTPUT}. In other words, all of T_{INPUT} is transferred through the clutch-pack **74** during clutch lock-up. The clutch-pack **74** includes a temperature sensor **92** that generates a temperature signal (C_{TEMP}).

[0027] Referring now to **FIG. 3**, T_{CALC} is determined based on motor data, V_{MOTOR}, M_{POS}, M_{TEMP}, I_{MOTOR}, shift system data and clutch data. More particularly, the motor module **80** determines a physical characteristic of the motor **70** (i.e., armature position) based on electrical motor characteristics (i.e. the motor data, V_{MOTOR} and I_{MOTOR}) and physical motor characteristics (i.e., M_{POS} and M_{TEMP}). The motor module **80** also accounts for the gear ratios of the gear reduction system. The motor module **80** generates a clutch operator interconnection position (P_{COINT}) based on the motor data, V_{MOTOR}, M_{POS} and M_{TEMP} and a resistance torque (T_{RES}). T_{RES} is determined as discussed in further detail below. P_{COINT} indicates the rotational position of the physical component (e.g., screw) that interconnects the motor **70** and the clutch operator mechanism **72**.

[0028] The clutch operator module **82** determines a clutch interconnection position (P_{CINT}) based on the clutch operator data, P_{COINT} and a resistance force (F_{RES}). F_{RES} is determined by the clutch model **84** as discussed in further detail below. The shift system module **82** also calculates T_{RES}, which is fed back to the motor module **80**. The clutch

module **84** calculates T_{CALC} based on clutch data, C_{TEMP}, wheel velocities, a nominal kiss point (NOM_{KP}) a corrected kiss point ($CORR_{KP}$) and P_{CINT}. The clutch module **84** also calculates F_{RES}, which is fed back to the shift system module **82**.

[0029] Referring now to **FIG. 4**, the motor module **80** will be discussed in further detail. The motor data is provided by the motor manufacturer and includes a current to torque conversion factor (k_T) a back EMF constant (k_E), brake on drag, brake off drag, viscous drag, coil resistance (R_{COIL}), inertia and gear ratio. The motor module **80** includes a current calculating module **100**, a drag torque calculating module **102**, a velocity calculating module **104** and a position calculating module **106**. The current calculating module **100** calculates a current (I) based on V_{MOTOR}, R_{COIL}, k_E, I_{MOTOR} and an angular velocity (ω_{MOTOR}). ω_{MOTOR} is calculated by the velocity calculating module **104** as discussed in further detail below. A multiplier **108** multiplies I by k_T to provide an indicated motor torque ($T_{MOTORIND}$).

[0030] The drag torque calculating module **102** calculates a brake drag torque ($T_{DRAGBRK}$) and a viscous damper drag torque (T_{DRAGVD}) based on ω_{MOTOR}, a brake enable signal and the viscous drag motor data. More particularly, $T_{DRAGBRK}$ is calculated based on ω_{MOTOR} and either the brake on drag or the brake off drag motor data. If the brake enable signal indicates brake on, $T_{DRAGBRK}$ is determined based on the brake on drag motor data. If the brake enable signal indicates brake off, $T_{DRAGBRK}$ is determined based on the brake off motor data. T_{DRAGVD} is determined based on ω_{MOTOR} and the viscous drag motor data. $T_{DRAGBRK}$ and T_{DRAGVD} are subtracted from T_{MOTOR} by a summer **110** to provide an adjusted motor torque ($T_{MOTORADJ}$).

[0031] T_{RES} is subtracted from $T_{MOTORADJ}$ by a summer **112** to provide an acceleration motor torque ($T_{MOTORACC}$). $T_{MOTORACC}$ is multiplied by the inertia motor data to provide an angular acceleration (α_{MOTOR}). The velocity calculating module **104** calculates ω_{MOTOR} based on α_{MOTOR} and a time step (t_K). The position calculating module **106** calculates P_{COINT} based on ω_{MOTOR}, M_{POS}, t_K and the gear ratio motor data.

[0032] Referring now to **FIG. 5**, the clutch operator module **82** will be explained in detail. The clutch operator data includes a spring rate (k_{SPRING}), an efficiency (CO_{EFF}), a drag factor (CO_{DRAG}), a viscous damper drag factor (CO_{DRAGVD}), a position ratio (CO_{RATIO}) and an inertia ($CO_{INERTIA}$). The clutch operator module **82** includes a drag calculating module **114**, a velocity calculating module **116** and a position calculating module **118**. A clutch operator position (P_{CO}) is subtracted from P_{COINT} by a summer **120** to provide a position error (P_{ERROR}). P_{CO} is calculated by the position calculating module **118** as discussed below. A multiplier **122** multiplies P_{ERROR} and k_{SPRING} to provide T_{RES}.

[0033] The drag calculating module **114** calculates a clutch operator torque (T_{CO}) based on CO_{EFF}, CO_{DRAG}, CO_{DRAGVD}, T_{RES} and a clutch operator angular velocity (ω_{CO}). More particularly, the drag calculating module **114** updates T_{RES} to account for efficiency losses and calculates a drag torque and a viscous damper drag torque. The drag torque and viscous damper drag torque are subtracted from the updated T_{RES} to provide T_{CO}. An inertia torque ($T_{INERTIA}$) is determined as the product of F_{RES} and CO_{RATIO} by a multiplier **124**. $T_{INERTIA}$ is subtracted from T_{CO} by a summer **126** to provide a clutch operator acceleration torque (T_{COACC}). A clutch operator angular acceleration (α_{CO}) is determined as the product of T_{COACC} and $CO_{INERTIA}$ by a multiplier **128**. The velocity calculating module **116** calculates ω_{CO} based on α_{CO} and t_K. The position calculating module **118** calculates P_{CO} based on ω_{CO} and t_K. P_{CINT} is determined as the product of P_{CO} and CO_{RATIO} by a multiplier **130**.

[0034] Referring now to **FIG. 6**, the clutch module **84** will be described in detail. The clutch data includes an active ready control factor and a back stop position. The clutch module **84** includes a force calculating module **132**, a slip speed calculating module **134**, a friction module **136** and a torque calculating module **138**. The force calculating module **132** determines F_{RES} and a clutch force (F_{CLUTCH}) based on the clutch data, a nominal kiss point (KP_{NOM}), P_{CINT} and a kiss point correction (KP_{CORR}). More particularly, P_{CINT} is corrected based on KP_{CORR}. KP_{CORR} is continuously updated to account for tolerances and wear in the clutch. F_{CLUTCH} is determined from a series of look-up tables based on the corrected P_{CINT}. F_{CLUTCH} is determined from test data averaged from various torque biasing systems instrumented to measure force at the clutch based on actuator position. Because there is normally a difference between engaging and releasing (i.e., hysteresis) multiple traces are collected. The direction of travel determines which table is used and filtering is applied to ensure smooth transitions.

[0035] F_{CLUTCH} is further determined based on a negative clutch force ($F_{CLUTCHNEG}$), the corrected P_{CINT}, KP_{NOM} and the active ready control factor. $F_{CLUTCHNEG}$ is a fictitious number that implies that the "actual" torque at the clutch is negative when the system is below the kisspoint of the clutch. In this manner, the system is maintained at the active ready position when there is a low torque request. This is achieved by providing a significant control error if the position is below the kisspoint. Without $F_{CLUTCHNEG}$, the system would calculate zero torque for any position below the kisspoint causing minimal control error for low torque requests regardless of position. Additionally, $F_{CLUTCHNEG}$ is a direct gain on position below kisspoint and is tuned for optimum response and stability. KP_{NOM} is a constant that is stored in memory and indicates the nominal kiss point (i.e., the point at which the clutch plates engage) for the particular clutch model. F_{CLUTCH} is calculated as the difference of $F_{CLUTCHINT}$ and $F_{CLUTCHNEG}$.

[0036] The slip speed calculating module **134** calculates wheel slip (v_{SLIP}) based on the wheel speed signals generated by the sensor group **56**. The friction calculating module **138** calculates a coefficient of friction (K_{FRICT}) based on F_{CLUTCH}, V_{SLIP} and C_{TEMP}. More particularly, the friction module **136** determines K_{FRICT} from a three-dimensional look-up table based on F_{CLUTCH}, V_{SLIP} and C_{TEMP}. The torque calculating module **138** calculates T_{CALC} based on K_{FRCIT} and F_{CLUTCH}. T_{CALC} is determined according to the following equation:

$$T_{CALC}=F_{CLUTCH}*N_{PLATES}*R_{EFF}*K_{FRICT}$$

where N_{PLATES} is the number of clutch plates and R_{EFF} is the effective radius of the clutch plates. N_{PLATES} and R_{EFF} are constants based on clutch geometry. No hysteresis is assumed.

[0037] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from

the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A power transmission device for a motor vehicle, comprising:

a torque biasing system having a clutch pack disposed between first and second rotary members;

a motor operable to manipulate engagement of said clutch pack based on a control signal, said motor having a position sensor operable to generate a position signal, a temperature sensor operable to generate a temperature signal and a current sensor operable to generate a current signal, and

a control system operable to generate said control signal based on a torque command and a calculated torque, wherein said calculated torque is determined based on a model of said torque biasing system, and wherein said calculated torque is determined based on at least one of said position signal, said temperature signal and said current signal.

2. The power transmission device of claim 1 wherein said torque biasing system further includes a clutch operator mechanism driven by said motor for imparting a clutch engagement force on said clutch pack.

3. The power transmission device of claim 1 wherein said control signal is based on a difference between said torque command and said calculated torque.

4. The power transmission device of claim 1 wherein said model of said torque biasing system includes a motor module, a clutch operator module and a clutch pack module.

5. The power transmission device of claim 1 wherein said control system includes a controller, said controller comprising:

a motor control module generating a motor control signal;

a motor module generating a calculated clutch operator position signal based on said motor control signal;

a clutch operator module generating a calculated clutch interconnection signal based on said calculated clutch operator position signal; and

a clutch module generating a calculated torque signal based on said calculated clutch interconnection signal;

wherein said motor control signal is based on said calculated torque signal.

6. The power transmission device of claim 5 wherein said calculated clutch operator position signal is generated by said motor module based on motor data including at least one of current to torque conversion factor data, back EMF constant data, brake-on drag data, brake-off drag data, viscous drag data, coil resistance data, inertia data, and gear ratio data.

7. The power transmission device of claim 5 wherein said calculated clutch operator position signal is generated by said motor module based on at least one of motor position data, motor temperature data, and motor electrical current data.

8. The power transmission device of claim 5 wherein said calculated clutch interconnection signal is generated by said clutch operator module based on clutch operator data including at least one of spring rate data, efficiency data, drag factor data, viscous damper drag factor data, position ratio data, and inertia data.

9. The power transmission device of claim 5 wherein said calculated torque signal is generated by said clutch module based on at least one of negative clutch force data, nominal kiss point data, kiss point correction data, number of clutch plates data, effective clutch plate radius data, clutch geometry data, cutch temperature data, and wheel slip data.

10. The power transmission device of claim 5 wherein said motor control module receives a torque command signal and generates said motor control signal based on a difference between said torque command signal and said calculated torque signal.

11. A power transmission device for a motor vehicle, comprising:

a torque biasing system having a clutch pack disposed between first and second rotary members;

a motor operable to manipulate engagement of said clutch pack based on a control signal; and

a control module operable to generate said control signal based on a torque command and a calculated torque, wherein said calculated torque is determined based on a model of said torque biasing system, and wherein a temperature sensor associated with said clutch pack generates a temperature signal that is used by said control module to determine said calculated torque.

12. The power transmission device of claim 11 wherein said torque biasing system further includes a clutch operator mechanism driven by said motor for imparting a clutch engagement force on said clutch pack.

13. The power transmission device of claim 11 wherein said control signal is based on a difference between said torque command and said calculated torque.

14. The power transmission device of claim 11 wherein said model of said torque biasing system includes a motor module, a clutch operator module and a clutch pack module.

15. The power transmission device of claim 11 wherein said control system includes a controller, said controller comprising:

a motor control module generating a motor control signal;

a motor module generating a calculated clutch operator position signal based on said motor control signal;

a clutch operator module generating a calculated clutch interconnection signal based on said calculated clutch operator position signal; and

a clutch module generating a calculated torque signal based on said calculated clutch interconnection signal;

wherein said motor control signal is based on said calculated torque signal.

16. The power transmission device of claim 15 wherein said motor control module receives a torque command signal and generates said motor control signal based on a difference between said torque command signal and said calculated torque signal.

17. A power transmission device for a motor vehicle, comprising:

a torque biasing system having a clutch pack disposed between first and second rotary members;

a motor operable to manipulate engagement of said clutch pack based on a control signal; and

a control module operable to generate said control signal based on a torque command and a calculated torque, wherein said calculated torque is based on a calculated interconnection position of said clutch pack, and wherein said interconnection position is based on a model of said torque biasing system.

18. The power transmission device of claim 17 wherein said torque biasing system further includes a clutch operator mechanism driven by said motor for imparting a clutch engagement force on said clutch pack.

19. The power transmission device of claim 17 wherein said control signal is based on a difference between said torque command and said calculated torque.

20. The power transmission device of claim 17 wherein said model of said torque biasing system includes a motor module, a clutch operator module and a clutch pack module.

21. The power transmission device of claim 17 wherein said control system includes a controller, said controller comprising:

a motor control module generating a motor control signal;

a motor module generating a calculated clutch operator position signal based on said motor control signal;

a clutch operator module generating a calculated clutch interconnection signal based on said calculated clutch operator position signal; and

a clutch module generating a calculated torque signal based on said calculated clutch interconnection signal;

wherein said motor control signal is based on said calculated torque signal.

22. The power transmission device of claim 21 wherein said calculated clutch operator position signal is generated by said motor module based on motor data including at least one of current to torque conversion factor data, back EMF constant data, brake-on drag data, brake-off drag data, viscous drag data, coil resistance data, inertia data, and gear ratio data.

23. The power transmission device of claim 21 wherein said calculated clutch operator position signal is generated by said motor module based on at least one of motor position data, motor temperature data, and motor electrical current data.

24. The power transmission device of claim 21 wherein said calculated clutch interconnection signal is generated by said clutch operator module based on clutch operator data including at least one of spring rate data, efficiency data, drag factor data, viscous damper drag factor data, position ratio data, and inertia data.

25. The power transmission device of claim 21 wherein said calculated torque signal is generated by said clutch module based on at least one of negative clutch force data, nominal kiss point data, kiss point correction data, number of clutch plates data, effective clutch plate radius data, clutch geometry data, cutch temperature data, and wheel slip data.

26. The power transmission device of claim 21 wherein said motor control module receives a torque command signal and generates said motor control signal based on a difference between said torque command signal and said calculated torque signal.

27. A power transmission device for a motor vehicle, comprising:

a torque biasing system having a clutch pack disposed between first and second rotary members;

a motor operable to manipulate engagement of said clutch pack based on a control signal; and

a control module operable to generate said control signal based on a torque command and a calculated torque, wherein said calculated torque is determined based on a model of said torque biasing system which includes a motor module, a clutch operator module and a clutch pack module.

28. The power transmission device of claim 27 wherein said torque biasing system further includes a clutch operator mechanism driven by said motor for imparting a clutch engagement force on said clutch pack.

29. The power transmission device of claim 27 wherein said control signal is based on a difference between said torque command and said calculated torque.

30. The power transmission device of claim 27 wherein said model of said torque biasing system includes a motor module, a clutch operator module and a clutch pack module.

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