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(54) TITLE OF INVENTION

MOTOR CONTROL DEVICE FOR BATTERY VEHICLE

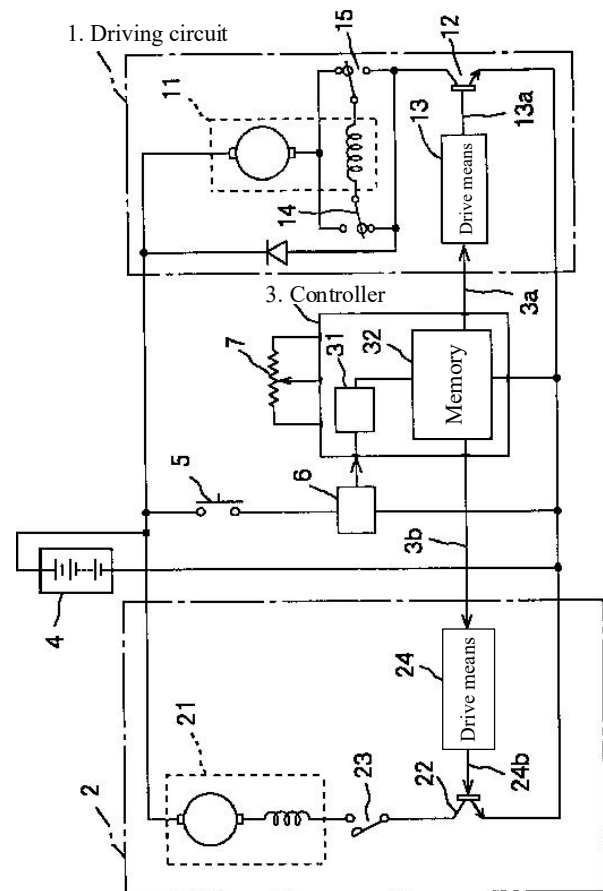
(57) [Abstract]

PURPOSE

An object of the present invention is to provide a motor control device that maintains operability at full charge even if battery voltage drops due to discharging.

CONFIGURATION

The present invention includes detecting means 31 for detecting battery voltage and duty setting means 32 that performs a duty command based on various detection values of battery 4 voltage detected by the detecting means 31, where the duty setting means 32 commands duty that is inversely proportional to battery voltage drop characteristics. Thus, the maximum rotational speed of the motor that is dependent on battery voltage is substantially constant, regardless of the battery charge state, maintaining operability with no abnormal feel while battery voltage is within a usage range.



What Is Claimed Is:

[Claim 1] A motor control device, comprising:
 a motor driven by power supplied from a battery;
 a chopper circuit that intermittently supplies battery power to the motor;
 drive means for driving the chopper circuit by outputting a pulse signal that defines the intermittent interval of the chopper circuit to the chopper circuit;
 detecting means for detecting the voltage of the battery; and
 duty setting means for commanding adding to the drive means a pulse signal duty with inverse proportional characteristics relative to voltage drop characteristics from the voltage at full charge to the limit voltage based on each detection value from the detecting means.

DETAILED DESCRIPTION OF THE INVENTION

[0001]

INDUSTRIAL FIELD OF APPLICATION

The present invention relates to a motor control device of a battery vehicle and in particular to a device that enables obtaining a constant sense of operation regardless of battery charge state.

[0002]

CONVENTIONAL TECHNOLOGY

Typically, battery vehicles such as an electric forklift use a motor for cargo and for driving, and for example, a DC motor is rotation driven by a chopper circuit intermittently operated by a pulse signal, and the rotation speed thereof is controlled using the duty of the pulse signal. Furthermore, the duty of the pulse signal is commanded by a controller having a central processing function. In this case, duty that imparts the rotational speed corresponding to the set operating speed of the actuator is set in the motor for cargo handling and duty imparting rotational speed corresponding to the depression angle of an accelerator pedal (hereinafter, accelerator depression angle) is set for the driving motor. [0003] Here, the responsiveness of a battery vehicle for cargo handling and driving operation, or so-called cargo handling feeling or driving feeling is said to be favorable when the response level of the driving member relative to operation performed matches what is anticipated. Therefore, correlation of the pulse signal duty and the motor rotational speed is important so that this manner of operability is not impaired.

[0004]

PROBLEM TO BE RESOLVED BY THE INVENTION

However, with this type of vehicle, the battery has a charge life and typically charging is performed when the battery voltage drops from battery voltage when battery is fully charged (100% charge rate) to a limit voltage (for example, 80% discharge). The process of decreasing from the voltage at full charge to limit voltage is nearly linear. Therefore, battery loads such as control devices are designed to operate stably at this type of limit voltage.

[0005] However, maximum rotational speed of the motor is defined depending on battery voltage and for this chopper control method, the motor maximum rotational speed for a constant duty changes based on voltage within the operating range, as illustrated in FIG. 4. Therefore, in the case of a cargo handling circuit of a conventional battery vehicle, actuator operation delay gradually progresses and operating

efficiency degrades and in the case of the driving circuit, acceleration performance is impaired due to a decrease in driving speed.

[0006] An object of the present invention is to provide motor control technology for continually maintaining operability with no abnormal feel while battery voltage is within the operating range.

[0007]

MEANS FOR SOLVING THE PROBLEM

The present invention includes detecting means for detecting battery voltage and duty setting means for commanding that the duty of the pulse signal be increased inversely proportional to a voltage drop characteristic from the voltage when the battery is fully charged to the limit voltage, based on the detection values from the detecting means.

[0008]

FUNCTION

This manner of motor control device enables control increasing the pulse signal duty inversely proportional to the voltage drop of the battery. In other words, in practice, the maximum rotational speed of the motor dependent on battery voltage can be controlled to nearly a constant level regardless of battery voltage.

[0009]

EMBODIMENTS

An embodiment applying the present invention to an electric forklift will be described in detail below. A motor control device for an electric forklift illustrated in FIG. 1 is configured to set the current flowing in each of DC motors 11 and 21 in a driving circuit 1 and a cargo handling circuit 2 using a duty command from a controller 3 as a central processing unit and the present invention is configured to set the duty command according to voltage of a battery 4. [0010] The driving circuit 1 includes the DC motor 11 connected to the battery 4, a transistor 12 that constitutes a chopper circuit, and drive means 13 for supplying a pulse signal 13a to this transistor 12 for intermittent operation of this transistor 12. The intermittent operation of this transistor 12 controls the current supplied from the battery 4 to the DC motor 11. In addition, the direction current is supplied to the DC motor 11 is reversed by switching two electromagnetic contactors 14 and 15 interlocked with the operation of a forward/reverse switch (not shown). Thus, the DC motor 11 interlocked with drive wheels for driving is driven in forward and reverse directions enabling the vehicle to move forward and backward.

[0011] The cargo handling circuit 2 includes a DC motor 21 connected to the battery 4, a transistor 22 that constitutes a chopper circuit, an electromagnetic contactor 23 that intermittently connects a current path between the transistor 22 and the DC motor 21 in conjunction with operation of a cargo handling switch (not shown), and drive means 24 for supplying a pulse signal 24b to the transistor 22 to cause intermittent operation of the transistor 22.

The DC motor 21 drives, for example, a constant rate hydraulic pump, driving the hydraulic pump with a rotational speed corresponding to the intermittent operation of the transistor 22 and thus setting the operating speed of the actuator.

[0012] On the other hand, the controller 3 has a function of setting the command duty of the pulse signal 13a for the driving circuit 1 and the pulse signal 24b for the cargo handling circuit 2 according to the voltage of the battery 4. In other words, the controller 3 is connected to a constant voltage power supply circuit 6 that supplies voltage from the battery 4 via a key switch 5 and the controller 3 is driven by means of the stabilized output of the constant voltage power supply circuit 6. The controller 3 has detecting means 31 for detecting the output of the constant voltage power supply circuit 6 as the voltage of the battery 4.

[0013] Each of the detection values of the detecting means 31 is processing using duty setting means for commanding each of the duties of the pulse signals 13a and 24b in the driving circuit 1 and the cargo handling circuit 2. This duty setting means reads and controls from the memory 32, control characteristics (FIG. 2) in which command duty is increased inversely proportional to voltage characteristics where the voltage of the battery 4 drops from fully charged voltage characteristic to the limit voltage at 80% discharge and further a control characteristic group (FIG. 3) in which the duty gradient for changes in the accelerator depression angle is increased inversely proportional to the voltage characteristics described above as a gradient parameter for the battery voltage detection value. Data read from the memory 32 is supplied as control signals 3a and 3b that command duties of the drive means 13 of the driving circuit 1 and drive means 24 of the cargo handling circuit 2.

[0014] Next, operation of the embodiment described above will be described with reference to FIG. 1 to FIG. 3. When the key switch 5 is turned ON, the constant voltage power supply circuit 6 generates an output voltage and the controller 3 starts operating. Furthermore, when the electromagnetic contactor 23 for the cargo handling hydraulic pump is turned ON, the output voltage of the constant voltage power supply circuit 6 is detected by the detecting means 31 as the battery 4 voltage. Here, when the battery 4 is in a fully charged state, a detection voltage V_a is detected. From the control characteristics of FIG. 2 based on the detected value V_a , the controller 3 reads data such as 80% as the command duty. This data is supplied to the drive means 24 as the control signal 3b. Thus, the drive means 24 outputs a pulse signal 24b with a duty of 80% and the transistor 22 supplies current to the DC motor 21 with intermittent operation of 80% ON time. Therefore, when fully charged, the DC motor 21 drives the hydraulic pump with a maximum rotational speed corresponding to a duty of 80%.

[0015] In a similar manner, when the battery 4 reaches the limit voltage, from the control characteristics of FIG. 2 based on the detected value V_b , the controller 3 reads data setting command duty to 100% and the control signal 3b based on this data is supplied to the drive means 24 and the DC motor 21 drives the hydraulic pump at a maximum rotational speed corresponding to a duty of 100%. The controller 3 detects the voltage between the detected value V_a to V_b at the resolution defined by the detection capability of the detecting means 31 and submits a command of a pulse

signal 13b with duty increased inverse proportional to the voltage characteristics of the battery 4 to the drive means 24. Thus, the maximum rotational speed at full charge of the DC motor 21 is substantially maintained regardless of drop in battery voltage enabling a stabilized cargo handling feeling. [0016] Next, in the case of driving operation, the controller 3 reads duty gradient characteristics according to the detected value from the detecting means 31 from the control characteristic group of FIG. 3. Furthermore, when the accelerator is pressed, the duty corresponding to the output value θ of the potentiometer 7 showing the depression angle thereof is set from the characteristics read as described above and a control signal 3a that achieves this level of duty including the duty gradient of these characteristics as read is supplied to the drive means 13. In other words, when fully charged, the duty gradient is read as the smallest characteristic a based on the detected value V_a . With this characteristic a, the duty of the accelerator depression angle to the maximum effective angle θ_{MAX} is, for example, 80%. When the battery voltage drops to the limit voltage, the characteristic b with the maximum duty gradient is read based on the detected value V_b . With this characteristic b, the duty with respect to the maximum effective angle θ_{MAX} is 100%. Similarly, relative to various detection values between detection value V_a and V_b , the controller 3 reads characteristics increasing the duty gradient inversely proportional to battery voltage drop characteristics. Thus, in driving operation, substantially stable operability with nearly constant acceleration from fully charged to limit voltage can be obtained regardless of battery voltage drop.

[0017] Note that in the embodiment described above, control characteristics of the duty command to the driving circuit 1 are written to the memory 32 in advance but in another embodiment, the same control characteristics may be calculated through computation. This would be calculating each command duty and accelerator depression angle data for the offset setting point O as well as command duty relative to each accelerator depression angle based on the detection value of battery voltage corresponding to duty gradient.

[0018]

EFFECT OF THE INVENTION

As described above, with the present invention, a command is performed such that the duty is increased with characteristics inverse to battery voltage characteristics within operation limits so maximum rotational speed of the motor dependent on battery voltage is practically constant relative to battery voltage within operation limits, enabling obtaining stable operability regardless of battery state of charge.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a configuration diagram illustrating the motor control device of an electric forklift to which the present invention is applied.

FIG. 2 is a characteristics diagram illustrating battery voltage vs. duty control characteristics set according to the present invention.

FIG. 3 is a characteristics diagram illustrating duty gradient control characteristics relative to battery voltage set according to the present invention.

FIG. 4 is a graph illustrating the relationship between battery voltage and maximum rotational speed of a motor to date.

LIST OF REFERENCE NUMERALS

1. Driving circuit, 2. Cargo handling circuit, 3. Controller
(31. Detecting means, 32. Memory (duty setting means), 4.

Battery, 7. Potentiometer, 11, 21. DC motor, 12, 22.
Transistor (chopper circuit), 13, 24. Drive means, 3a, 3b.
Control signal, 13a, 13b. Pulse signal.

FIG. 1

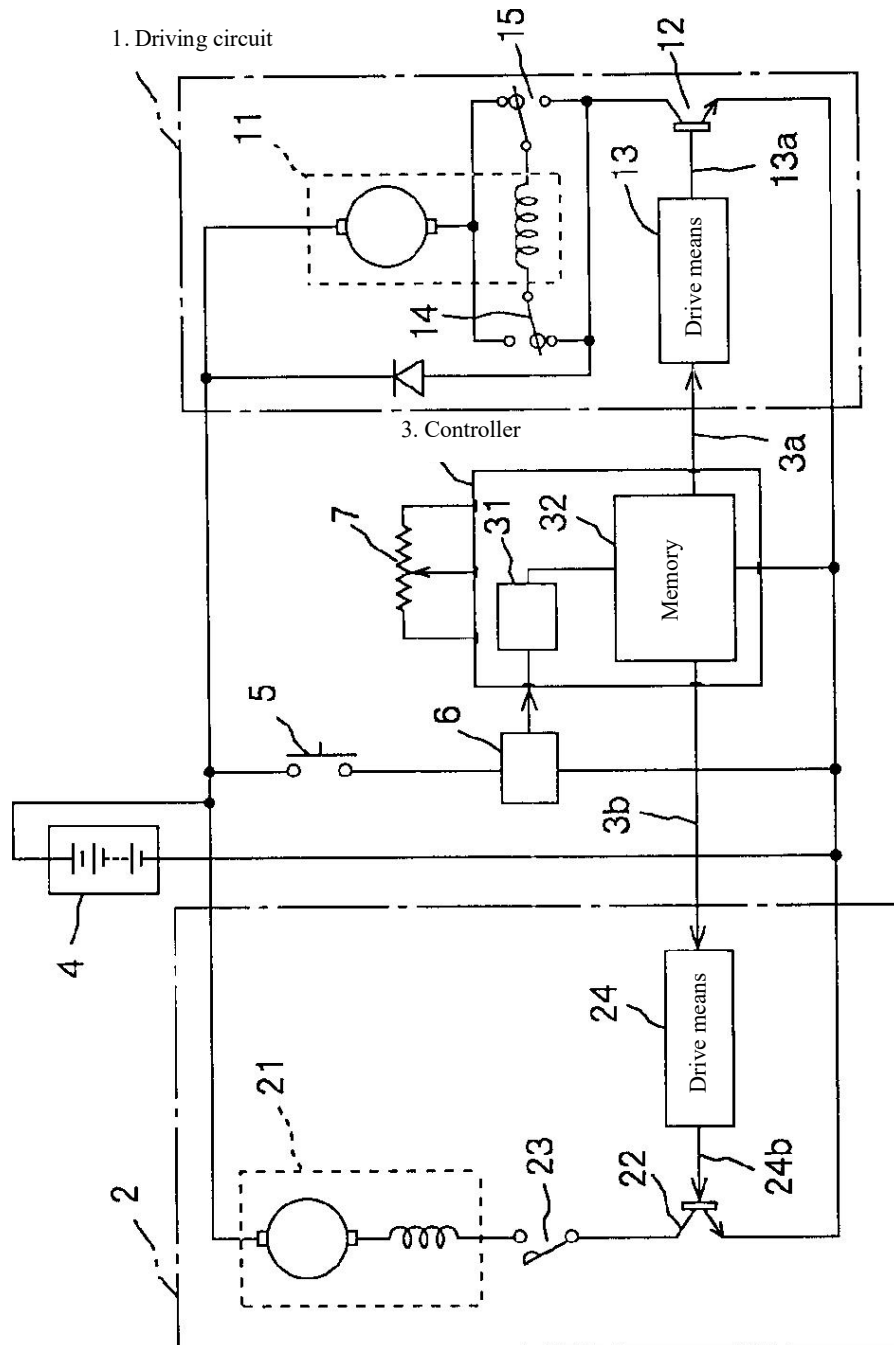


FIG. 2

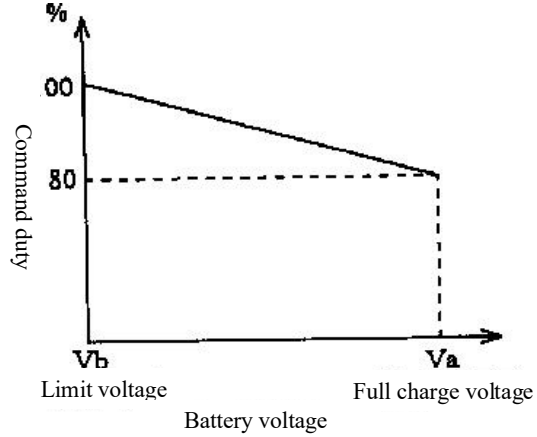


FIG. 3

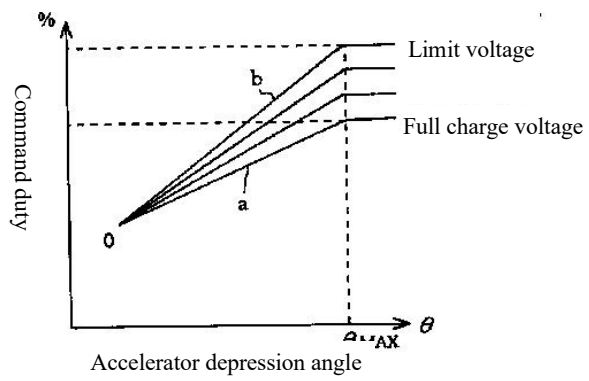


FIG. 4

