

SERVO MOTOR CONTROL SYSTEM AND METHOD OF AUTO-DETECTION OF TYPES OF SERVO MOTORS

Field of the Invention

[0001] The present invention generally relates to servo motor control systems, and more particularly to a servo motor control system with an auto-detect circuit and a method of auto-detection of the types of servo motors.

Background of the Invention

[0002] Robots are commonly used in automation, production and assembly industries, and space exploration. A mixture of servo motors including DC brushed motors and DC three-phase brushless motors has been employed in complicated robotic systems so as to combine flexibility, power, efficiency, compactness, cost effectiveness and speed.

[0003] DC motors convert electrical energy into mechanical energy. DC brushed motors contain internal brushes for commutation. They have a positive terminal and a negative terminal through which external power is supplied. They are usually fitted with encoders for closed-loop position feedback. FIG 1 shows a functional block diagram of a conventional DC brushed motor control system. The control system 1 comprises a control means 2, a driver circuit 3 with a pulse width modulation (PWM) generator 4 and a power amplifier 5, a DC brushed motor with encoder feedback 6, and a position decoder 7. With a defined motor type, the control means 2 supplies commanding signals to the driver circuit 3 and modifies its commanding signals according to the feedback signals from the position decoder 7. The driver circuit 3 generates the voltage supply of PWM in response to the commanding signals and amplifies the voltage supply before it is applied to the DC brushed motor. The position decoder 7 will feedback to the control means to stop the motor when it detects that the motor has reached its predetermined position. It is to be noted that the power source is not shown.

[0004] DC brushless motors do not contain brushes for commutation. Each DC brushless motor is a 3-phase system where power is supplied through 3 terminals. They are usually fitted with 3-phase Hall Effect sensors for rotor position feedback. FIG 2 shows a functional block diagram of a conventional DC brushless motor control system.

The control system **10** comprises a control means **11**, a driver circuit **12** with a 3-phase PWM generator **13** and a power amplifier **14**, a DC brushless motor **15**, and a position decoder **16**. As evident from FIG 2, the operation of the DC brushless motor is similar to the DC brushed motor but the driver circuit and PWM commutator signals are totally different.

[0005] As discussed above, different servo motors are usually driven by their corresponding drivers with different control circuitries. Thus, switching between two different servo motors requires a complete change in the control circuit. Moreover, prior to implementing any combination of drivers and motors, designers need to spend time to understand the detail settings of such components and connect them correctly.

[0006] In order to control different types of motors without the need to design different control circuitries for each type of motors, hybrid drivers have been disclosed in the prior art. For example, U.S. Pat. 6,404,150 discloses an electric vehicle accessory motor drive power supply system that utilizes a single power supply design to provide efficient variable speed motor control to both brushed and brushless motors. Commercial chipsets that are capable of driving DC brushed and brushless motors are also available. For example, Performance Motion Devices provides such chipsets.

[0007] Although these commercial chipsets are capable of driving different types of motors, users are still required to define the type of motors they are controlling through software. Defining the type of motors wrongly may damage the motors. Moreover, if a motor is replaced by another type, users would need to modify the software.

[0008] Therefore, there is a need to have a servo motor control system that automatically detects the type of motor that is electrically connected to a hybrid driver, resulting in elimination of the need that a user has to define the type of motor to be driven or make changes in the software. Here, the present invention satisfies this need by providing a servo motor control system that comprises an auto-detect circuit that uses the available signal lines from the brushed and brushless motors to detect the type of DC motors attached. In addition, the present invention provides a method of auto-detecting the type of servo motors connected.

Summary of the Invention

[0009] In one aspect of the present invention, there is provided an auto-detection module that can be employed in a servo motor control system with a hybrid commutation control, wherein the hybrid commutation control can drive either a DC brushed motor or a DC brushless motor. In one embodiment, the auto-detection module comprises an electronic signal receiving means for receiving connection status signals when either the DC brushed motor or the DC brushless motor is connected to the hybrid commutation control; and an electronic digital circuit receiving the connection status signals from the electronic signal receiving means and confirming the type of the connected motor; thereby the auto-detection module sends a switch signal to the hybrid commutation control so that its driving mode is matching with the type of the connected motor. In one further embodiment of the auto-detection module, the electronic signal receiving means comprises three pins with internal pull-ups so that each pin will give a "1" for unconnected or a "0" for connected; and wherein the three pins can only connect with the three Hall Effect sensors of a brushless motor. In another further embodiment of the auto-detection module, the electronic digital circuit comprises a NAND gate for outputting 1 or 0 of the inputs from the three pins, and a 3-stage digital latch for confirming the type of the connected motor.

[0010] In another aspect of the present invention, there is provided a servo motor control system that comprises a hybrid commutation control being capable of driving either a DC brushed servo motor or a DC brushless servo motor; and an auto-detection module electronically connected with the hybrid commutation control. In one embodiment of the servo motor control system, the auto-detection module comprises an electronic signal receiving means for receiving connection status signals when either the DC brushed motor or the DC brushless motor is connected to the hybrid commutation control; and an electronic digital circuit receiving the connection status signals from the electronic signal receiving means and confirming the type of the connected motor; thereby the auto-detection module sends a switch signal to the hybrid commutation control so that its driving mode is matching with the type of the connected motor. In another embodiment of the servo motor control system, the electronic signal receiving means comprises three pins with internal pull-ups so that each pin will give a "1" for unconnected; and wherein the three pins can only connect with the three Hall Effect sensors of a brushless motor. In one further embodiment of the servo motor control system, the electronic digital circuit

comprises a NAND gate for outputting 1 or 0 of the inputs from the three pins, and a 3-stage digital latch for confirming the type of the connected motor.

[0011] In another embodiment, the servo motor control system further comprises a controlling means for providing commanding signals to the hybrid commutation control; wherein the commanding signals are voltage signals that will be translated into motions by a servo motor that is electrically connected with the hybrid commutation control. In one further embodiment of the servo motor control system, the controlling means is a microprocessor. In yet another further embodiment of the servo motor control system, the microprocessor is a PC, Notebook, PDA, or any portable electronic device.

[0012] In yet another embodiment, the servo motor control system further comprises a feedback means for detecting the positions of the connected motor and inputting the information of detected positions of the motor into the controlling means, so that the controlling means changes the commanding signals to the hybrid commutation control accordingly.

[0013] In yet another aspect of the present invention, there is provided a method of auto-detection of the type of a motor electrically connected to a hybrid commutation control using the auto-detection module of Claim 1, wherein the hybrid commutation control is capable of driving either a DC brushed motor or a DC brushless motor. In one embodiment, the method comprises the following operations: receiving electronic signals indicating whether the Hall Effect sensors are present; and confirming the type of the connected motor; wherein, if there is no presence of Hall Effect sensors, the connected motor is a brushed motor; and wherein, if there is presence of any Hall Effect sensors, the connected motor is a brushless motor.

[0014] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0015] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0016] FIG 1 shows a functional block diagram of a conventional DC brushed motor control system.

[0017] FIG 2 shows a functional block diagram of a conventional DC brushless motor control system.

[0018] FIG 3 shows a functional block diagram of the servo motor control system in accordance with one embodiment of the present invention.

[0019] FIG 4 shows an exemplary auto-detection circuit in accordance with one embodiment of the present invention.

[0020] FIG 5 shows an exemplary functional block diagram of the servo motor control system illustrating the auto-detection and control of a DC brushed motor in accordance with one embodiment of the present invention.

[0021] FIG 6 shows an exemplary functional block diagram of the servo motor control system illustrating the auto-detection and control of a DC brushless motor in accordance with one embodiment of the present invention.

[0022] FIG 7 is a flowchart of the operation of the auto-detection of the type of motors connected to the hybrid commutation control in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0023] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0024] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0025] In one aspect of the present invention, there is provided a servo motor control system that has the "plug-and-play" feature for controlling either a DC brushed or brushless motor without human intervention. FIG 3 shows a functional block diagram of the servo motor control system in accordance with one embodiment of the present invention. The servo motor control system 30 comprises a controller 31, a hybrid commutation control 32, a power amplifier 33, a DC brushed/brushless motor 34, an auto-detection 35, and a position decoder 36. It is to be noted that many components and

aspects are well known to those skilled in the art so that no details will be described herein in order not to obscure the principles of the present invention.

[0026] The controller **31** may be any electronic microprocessor that has the capacity of supplying commanding signals to the hybrid commutation control **32**. For example, the microprocessor may be a PC, Notebook, PDA or any other portable electronic devices. The controller **31** has the means serving as a GUI so that a user can input into the controller the desired motions to be carried out by the attached motors. In addition, the controller **31** receives the position feedback of the attached motors via the position decoder **36**.

[0027] The hybrid commutation control **32** comprises an electronic circuit that is capable of supplying electronic signals to drive either a DC brushed motor or a DC brushless motor. As discussed above, such a hybrid control chipset is available. Therefore, there are no details needed herein. One available commercial hybrid control chipset is MC2840 from Performance Motion Devices (55 Old Bedford Road Lincoln, MA 01773, USA). The power amplifier **33** outputs its electronic signals in three phases. A suitable amplifier is known to those skilled in the art. L6234 from STMicroelectronics is one available commercial amplifier (39, Chemin du Champ des Filles C. P. 21 CH1228 Plan-Les-Ouates GENEVA, Switzerland). The DC brushed/brushless motors are also well known to those in the art. Upon receiving of the commanding signals from the controller **31**, the hybrid commutation control **32** will supply the electronic signals via the power amplifier to the attached motor according to the motor type.

[0028] The auto-detection module **35** detects automatically the type of the motor that is electrically connected to the driver of the servo motor control system when the control system is turned on or when the connected motor is changed. The details of the auto-detection will be provided hereinafter. The auto-detection module **35** will notify the hybrid commutation control **32** to the detected motor type so that the hybrid commutation control **32** will have the correct driver circuit for the connected motor.

[0029] The auto-detection module **35** comprises three pins H1, H2, and H3 receiving feedback signals from the connected motors. For a DC brushless motor, the pins are connected to the three Hall Effect sensors. When a DC servo brushed motor is

connected, the pins are unconnected. The H1, H2, and H3 pins are designed to have internal pull-ups. Hence their logic is “1” if left unconnected.

[0030] If a brushless motor is connected, there are 6 possible permutations that can occur to the three pins at any instant of time. Table 1 below lists all the possible input permutations for a brushless motor.

[0031] Table 1. Possible input permutations for a brushless motor

H1	H2	H3
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0

[0032] If a brushed motor is connected, H1, H2 and H3 are left unconnected. These will always be pulled high by the internal pull-ups. Therefore, as summarized in Table 2, the only permutation possible for a brushed motor is H1=H2=H3=1.

[0033] Table 2. Possible input permutations for a brushed motor

H1	H2	H3
1	1	1

[0034] Comparing the two tables, it can be easily noted that there are differences in the possible permutations. Hence an auto-detection circuit to differentiate the two types of motors can be readily designed. An exemplary auto-detection circuit is shown in FIG 4. Since the case where H1=H2=H3=1 can only occur for a brushed motor, this circuit is designed to detect this case. A NAND gate accepts the 3 inputs H1, H2 and H3. The output of this three-input NAND gate will be “0” only if all the 3 inputs are “1”. The output of this three-input NAND gate passes through a three-stage digital latch. The 3-stage digital latch is necessary to detect the case where H1=H2=H3=1. The latch will subsequently send the result of the type of motor connected on SEL pin. The resulting logic on the SEL pin is used to switch between single phase (for DC brushed motors) and three phase control (for DC brushless motors).

[0035] The position decoder 36 comprises an electronic circuit that is capable of detecting the positions of the connected motor, either a DC brushed or brushless one. One

such commercially available example is HCTC-2020 from Hewlett Packard (3000 Hanover Street, Palo Alto, CA 94304-1185 USA).

[0036] Now referring to FIG 5, there is provided an exemplary functional block diagram of the servo motor control system illustrating the auto-detection and control of a DC brushed motor in accordance with one embodiment of the present invention. The diagram shown in FIG 5 is very similar to the one shown in FIG 3 except for the following differences. In FIG 5, the hybrid commutation control **32**, the auto-detection module **36**, and the position decoder **37** form the driver module **38**. The DC brushed motor is detected by the auto-detection module because the three pins H1, H2, and H3 all have a logic state of "1". Then the auto-detection module **35** switches the hybrid commutation control **32** into a driving mode for a brushed motor. As seen from FIG 5, the Phase C control is open; the three pins are open; the position decoder uses the Encoder Channel A&B to provide feedback signals to the Controller.

[0037] Now referring to FIG 6, there is provided an exemplary functional block diagram of the servo motor control system illustrating the auto-detection and control of a DC brushless motor in accordance with one embodiment of the present invention. The functional blocks in FIG 6 are identical to the ones shown in FIG 5. FIG 6 shows that when a DC brushless motor is detected by the connections between the pins and Hall Effect sensors, the hybrid commutation control is switched to the three-phase output, and the position decoder uses channel A and B signals to provide feedback signals to the controller. It is, however, possible to design a position decoder to read in the Hall Effect sensors as feedback to the controller.

[0038] Now referring to FIG 7, there is provided a flowchart showing the main steps of the auto-detection module operation in accordance with one embodiment of the present invention. The operation **70** automatically starts when the motor is electrically connected **71** to the driver. Then the auto-detection module receives input signals from the three pins H1, H2, and H3 **72**. Then, the NAND gate outputs **73** 1 or 0 depending on inputs of the pins H1, H2, and H3. The type of motor connected is confirmed by 3-stage digital latch **74**. Then, SEL pin=0 or 1 differentiates brushed or brushless motors. Finally, the auto-detection module sending switch signals to the hybrid commutation control; thereby the driving mode within the hybrid commutation control matches the type of the motor connected.

[0039] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed by one or more of the appended claims. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. An auto-detection module that can be employed in a servo motor control system with a hybrid commutation control, wherein the hybrid commutation control can drive either a DC brushed motor or a DC brushless motor, said auto-detection module comprising:
 - an electronic signal receiving means for receiving connection status signals when either the DC brushed motor or the DC brushless motor is connected to the hybrid commutation control; and
 - an electronic digital circuit receiving the connection status signals from the electronic signal receiving means and confirming the type of the connected motor;
 - thereby the auto-detection module sends a switch signal to the hybrid commutation control so that its driving mode is matching with the type of the connected motor.
2. The auto-detection module of claim 1, wherein the electronic signal receiving means comprises three pins with internal pull-ups so that each pin will give a "1" for unconnected and a "0" or "1" for connected; and wherein the three pins can only connect with the three Hall Effect sensors of a brushless motor.
3. The auto-detection module of claim 2, wherein the electronic digital circuit comprises a NAND gate for outputting 1 or 0 of the inputs from the three pins, and a 3-stage digital latch for confirming the type of the connected motor.
4. A servo motor control system comprising:
 - a hybrid commutation control being capable of driving either a DC brushed servo motor or a DC brushless servo motor; and
 - an auto-detection module electronically connected with the hybrid commutation control; wherein said auto-detection module comprises:

an electronic signal receiving means for receiving connection status signals when either the DC brushed motor or the DC brushless motor is connected to the hybrid commutation control; and

an electronic digital circuit receiving the connection status signals from the electronic signal receiving means and confirming the type of the connected motor;

thereby the auto-detection module sends a switch signal to the hybrid commutation control so that its driving mode is matching with the type of the connected motor.

5. The servo motor control system of claim 4, wherein the electronic signal receiving means comprises three pins with internal pull-ups so that each pin will give a "1" for unconnected; and wherein the three pins can only connect with the three Hall Effect sensors of a brushless motor.

6. The servo motor control system of claim 5, wherein the electronic digital circuit comprises a NAND gate for outputting 1 or 0 of the inputs from the three pins, and a 3-stage digital latch for confirming the type of the connected motor.

7. The servo motor control system of claim 4, further comprising
a controlling means for providing commanding signals to the hybrid commutation control; wherein the commanding signals are voltage signals that will be translated into motions by a servo motor that is electrically connected with the hybrid commutation control.

8. The servo motor control system of claim 7, wherein the controlling means is a microprocessor.

9. The servo motor control system of claim 8, wherein the microprocessor is a PC, Notebook, PDA, or any portable electronic device.

10. The servo motor control system of claim 4, further comprising a feedback means for detecting the positions of the connected motor and inputting the information of detected

positions of the motor into the controlling means, so that the controlling means changes the commanding signals to the hybrid commutation control accordingly.

11. A method of auto-detection of the type of a motor electrically connected to a hybrid commutation control using the auto-detection module of Claim 1, wherein the hybrid commutation control is capable of driving either a DC brushed motor or a DC brushless motor, said method comprises the following operations:

receiving electronic signals indicating whether the Hall Effect sensors are present;
and

confirming the type of the connected motor;

wherein, if there is no presence of Hall Effect sensors, the connected motor is a brushed motor; and

wherein, if there is presence of any Hall Effect sensors, the connected motor is a brushless motor.