Rotary drive for a data storage medium

The invention concerns a rotary drive having a brushless direct current motor, of the type having a brushless direct current motor with a permanently magnetic rotor and a wound stator comprising one or more winding coils, and a switch arrangement for activating the coil to generate a magnetic field producing rotary movement in the rotor, said drive also having a sensing device for reading signals recorded on the data storage medium.

Brushless d.c. motors are generally employed to drive data storage media e.g. data storage diskettes, whereby a hub locating the data storage medium is preferentially secured directly to the motor shaft so that the data storage medium can be directly driven. In order to ensure reliable, fault-free sensing of the data signals under conditions of high data packing density, it is necessary to drive the data storage medium at a uniformly high speed, rendering necessary maximum precision in the sequential switching of the power supply to the coils of the stator winding in the d.c. motor (commutation). Known d.c. motors possess for this purpose one or several sensors (e.g. Hall-effect devices) inside the motor housing in the immediate vicinity of the magnetic field operating the rotor, and these sensors are made to emit signals by the change in the magnetic field which occurs as the

rotor rotates. A circuit board also located in the motor housing contains the elements of a switch arrangement to which the sensor output signals are supplied and by which the appropriate commutation of the power supply energizing the winding is performed.

A further requirement of data medium drives is that their overall height be minimized; in the case of direct-driving d.c. motors, this significantly affects the overall axial length of the motor. A manufacturer of such motors must therefore endeavour to take every reasonable measure in order to minimize the overall axial height. In addition, the motor manufacturer has the latent task of manufacturing and supplying the motor more cheaply.

An object of the invention is to optimize and simplify the design and construction of a brushless d.c. motor type rotary drive for a data medium, while at the same time improving the system of motor winding energization.

According to the present invention, there is provided a rotary drive for a data storage medium, which drive comprises a brushless direct current motor with a permanently magnetic rotor and a wound stator having a winding comprising one or more winding coils; a switch arrangment for activating the winding to generate a magnetic field producing rotary movement in the rotor, and a sensing device for reading signals recorded on the data storage medium

and having an output connected to the switch arrangement for activation of the winding, wherein the said signals comprise control signals which identify at least those angular positions of the rotor, with respect to the stator, at which the power supply to the winding coil(s) has to be switched.

Preferably, the control signals comprise first and second control signals for each said angular position of the rotor, and the switch arrangement can be induced to activate the winding by a first control signal to interrupt the power supply to the winding coil(s) currently being energized, and by a subsequent second control signal to switch the power supply through to the next of the winding coil(s) in the energizing sequence.

In another preferred embodiment, on receipt of a control signal supplied by the sensing device, the switch arrangement for activating the winding interrupts the power supply to the energized winding coil(s), a delay device in the switch arrangement is activated and, on expiry of a delay time, the power supply is switched through to the next of the winding coil(s) in the energizing sequence.

In a further preferred embodiment at least two spaced control signals for each said angular position of the rotor are arranged in a circumferential direction on the data storage medium, and the switch arrangement comprises a measuring device to determine the

chronological interval between the two control signals which follow each other as the data storage medium rotates, the measurement result of which measuring device is evaluated to control the current amplitude or the number of current pulses to be supplied to the winding.

Advantageously, the switch arrangement includes a measuring device to determine the chronological interval between the paired control signals as the data storage medium rotates, a comparator to determine the deviation from a predetermined setpoint, and a delay device with varying or variable delay times, wherein a delay time of a magnitude commensurate with the deviation from the setpoint can be initiated by the switch arrangement between the interruption of the power supply to the currently energized winding coil(s) and energization of the next of the winding coil(s) in the energizing sequence. Alternatively, the switch arrangement comprises a measuring device to determine the chronological interval between the paired control signals as the data storage medium rotates, and a comparator to determine the deviation from a predetermined setpoint, and in accordance with the deviation from the setpoint, the switch arrangement switches through a greater or smaller current pulse to the next of the winding coil(s) in the energizing sequence.

Usually, the sensing device possesses a separate write (record) and/or read (sensing) head for the motor control signals and for the data signals to be written onto or read from the data storage medium. Suitably, the control signals are located on a concentric storage track of the data storage medium. Usually, the storage track is a radially outer track of the data storage medium.

Embodiments of the invention are illustrated in the following drawings in which:-

Fig. 1 is a schematic diagram of the invention;

Fig. 2 is a variant of the circuit arrangement in Fig. 1;

Fig. 3 is a flowchart of the circuit in Fig. 2

Fig. 4 is a further embodiment of the circuit arrangement in Fig. 1;

Fig. 5 is a flowchart of the circuit arrangement in Fig. 4;

Fig. 6 is another embodiment of the circuit arrangement in Fig. 1; and

Fig. 7 is a flowchart of the circuit arrangement in Fig. 6.

Fig. 1 shows the basic circuit diagram for an arrangement which incorporates a brushless d.c. external rotor motor 1. The 4-pole stator 2 has a winding consisting of four coils 3 to 6 and is surrounded in conventional manner by a permanent-magnet rotor 7.

Although, for the purpose of schematic simplication, a d.c. external rotor motor with an annular air-gap is shown, any design of motor can, of course, be applied provided it meets the requirement of a small overall axial length. Preferably a disk-rotor motor with a uniform air-gap is employed.

Rigidly connected to the shaft 8 of the motor 1 is a hub 9 onto which is positioned a data medium 10. The data medium 10 takes the form of a rigid or flexible data disk which carries data signals on concentric tracks. A write (recording)/read (sensing) head 11 is arranged above the data medium 10 such that it can be moved in a radial direction, by means of which head the data signals on concentric tracks of the data medium 10 can be recorded, sensed or erased. These signals are supplied via a connecting lead 12 to the write/read head 11 from a processing unit (not illustrated) in the usual way, or from this write/read head 11 to the processing unit. Depending on the type of data medium 10 and the storage process employed, the write/read head may be a magnetic head, an optical device, a laser head or a device for another recording/sensing process. The alignment of the write/read head 11 to the concentric data signal tracks can also be effected by a tilting motion instead of a radial movement.

In order to generate a magnetic field to produce the rotational motion of the rotor, the coils 3 to 6 of the stator winding must be energized in a certain sequence, for example one after the other in the sequence in which they are arranged. It should be noted in this context that the term "winding coils" also applies to the special case where a stator is only equipped with one coil which, depending on the rotor position, is either energized with current pulses in the same direction of flow or alternatively with current pulses of an opposing direction of flow, and that this term also covers any number of coils which form part of the stator winding and can be individually energized. The connection and disconnection of the current flow energizing the winding and the sequential switching (commutation) of the power supply to the winding coils 3 to 6 is controlled by a switch assembly 13 which, in the embodiment shown in Fig. 1, essentially contains a power supply switching device 14.

On an outer track 15 of the data medium 10, which can be sensed by means of a sensing head 16 corresponding to the write/read head 11 for the data signals, are recorded control signals for commutation of the winding current. Control signals picked up by the sensing head 16 are supplied via a connecting lead 17 to the switch assembly 13, the power supply switching device 14 of which commutates the operating current supplied by a

power source (not illustrated) via a power cable 18, from the energized winding coils 3 to 6 to the next of the winding coils 3 to 6 in the energizing sequence. In the simplest case, a single control signal is located on a track 15 for each commutation angular position, on receipt of which control signal the switch assembly 13 or its power supply switching device 14 cuts out the power supply to the energized coil and reconnects it for the next coil in sequence. As it is often advisable to provide a pause between disconnection and reconnection of the power supply, in order to prevent deleterious overlapping of electrical or magnetic phenomena, two control signals can be located on the track 15, with a defined interval in respect of one another, for each commutation angular position, to advantageous effect. Receipt of the first control signal at a commutation angular position then causes the power supply switching device 14 to interrupt the power supply to the motor winding along connecting lead 19, while receipt of the second control signal causes the power supply to be switched through to the next winding coil 3 to 6 in the energizing sequence. The interval between the control signal pairs for each commutation angular position on the data medium 10 thus determines the length of interruption in the energizing power supply.

As an alternative to the last-described embodiment, the switch assembly 20 shown in Fig. 2 can be employed instead of switch assembly 13 in Fig. 1, whereby only one control signal is again required on the data medium 10 for each commutation angular position. In addition to the power supply switching device 21, which in principle performs the same functions as described above, a delay device 22 is also provided. This delay device 22 can, for example, take the form of a clocked counter which is preset to a certain value, started by an input signal, counted down to zero at a fixed clock frequency, and deactivated again with the output of an end signal. The predetermined value at which the counter is set preferably should be adjustable.

As can be seen from the simplified flowchart in Fig. 3, a control signal supplied by the connecting lead 17 to the power supply switching device 21 from the rotating data medium 10 causes the power supply from lead 19 to be interrupted and starts the delay device 22. On expiry of the predetermined delay time, the delay device 22 is reset to its original setting, and an output signal is emitted to the power supply device 21 which then switches the power through to the next winding coil in energizing sequence in the motor 1. In the case of a solution in accordance with this embodiment, the magnitude of the interruption between power supply disconnection and reconnection to the

winding coils is thus determined by the delay device 22.

In the embodiment described above, a control circuit of a type which is already known and used in the prior art can, of course, also be provided in the power supply circuit of the motor, by means of which, for example, the amplitude of the current pulses can be adjusted to ensure constant motor speed.

The switch assembly 23 in accordance with Fig. 4 has, aside from a power supply switching device 24 and a delay device 25, an additional time measuring device 26 which can also take the form of a counter. This is started by an initial input signal and then counts upwards from zero at a fixed clock frequency until the timing operation is ended by a second input signal. The data medium 10 possesses for each switching operation two control signals separated by a suitable interval, which are picked up by the sensing head 16 and supplied via the connecting lead 17 to the sensing head 16 and supplied via the connecting lead 17 to the timer 26 as input signals. In accordance with the simplified flowchart in Fig. 5, receipt of the first of such a pair of control signals has the effect of starting the timer 26. The second control signal received by the now counting timer 26 stops the timing operation and causes the power supply switching device 24 to interrupt the power supply via lead 19 to the winding in motor 1. At the same time, the measured

value of the timer 26 is supplied to the delay device 25, the delay time of which is reduced by this value. Where a counter is used as the delay device 25, as basic value at which the counter is set would be reduced by the measured value. Once the delay device 25, which has been set to this corrected value and started, has counted down to the end of the delay, a signal is emitted to the power supply switching device 24, whereupon the power supply is switched through to the next winding coil in energizing sequence in the d.c. motor 1. The device combination in the embodiment thus provides the extremely rapid speed control response with only two control signals per commutation angular position, because, owing to the relatively large diameter of the data medium 10, a speed measurement path of a length suitable for evaluation is provided which corresponds to only a very small angular displacement value. The first control signal in each case is supplied in order to initiate the measuring operation, while the second control signal initiates power commutation. The power supply interruption, the length of which depends on the deviation of the actual speed from the reference speed, is, on the other hand, determined by the delay device 25.

An even more convenient solution is offered by the embodiment in Fig. 6, the function of which will be described on the basis of the simplified flowchart in Fig. 7. In addition to a power supply switching device 28 and a timer 29, the switch assembly 27 also contains a comparator 30 and a delay device 31 with several different or variable delay times. A table can, for example, be provided in this connection which contains different, individually addressable delay values to which a counter can be present in the manner described further above. The comparator 30 is provided with a comparison setpoint, which is predetermined but which can also be modified from a setpoint adjuster 32 via a setpoint input 33. In the case of this embodiment two control signals separated by an interval are again provided for each commutation angular position on the track 15 of the data medium 10, and these are sensed in sequence by the sensing head 16 as the data medium 10 rotates.

The first control signal in each pair starts the timer 29 - as already described in connection with Fig. 4 and Fig. 5 -, while the second control signal stops the timer 29 again (Fig. 7). Completion of the timing operation results in a signal being emitted to the power supply switching device 28, which then interrupts the power supply switching device 28, which then interrupts the power supply to the motor winding. The

value determined by the timer 29 is supplied to the comparator 30 which compares it with the setpoint. The result of the comparison is supplied to the delay device 31 and represents a variable - for example an address for a delay time table - for selection of the time delay between disconnection and reconnection of the energizing winding current. If the result of the comparison shows, for example, that the setpoint is smaller than the actual value measured by the timer 29, the output time from the delay device 31 must correspond to a power interruption period which is correspondingly less than the normal power interruption period, so that the duration of the winding energizing pulses is increased in order to accelerate the rotor 7 of the motor 1 which is rotating top slowly. In the opposite case, i.e. if the setpoint is greater than the measured value, the time output from the delay device 31 must initiate a longer interruption in the power supply. Following selection of a time delay corresponding to the setpoint/actual value deviation, and the expiry of this delay, the timer 29 is reset to its starting position and the power supply is switched through to the next winding coil in energizing sequence of the stator 2 by the power supply switching device 28.

This embodiment enables the motor and data medium speed to be adjusted or controlled in accordance with

desired velocity patterns, for example in the form of a desired acceleration or deceleration pattern, through the imposition of a setpoint (which, for example, may be taken from a setpoint able or computed). Moreover, depending on requirements, a more or less sophisticated delay device 31 can be employed in order to determine quantitatively and, immediately prior to commutation, implement a coarse or very fine correction to a speed deviation over a small angular displacement. Naturally, instead of varying the interruption to the power supply to the winding, the amplitude the current pulses or, in the case of a clocked power supply, the number of the individual pulses per winding energizing cycle can, for example, also be corrected.

The embodiments described only represent a small selection of the possibilities opened up by the inventive concept, which is widely variable and adaptable to special conditions or requirements by the expert. For example, it is conceivable that the control signal track can contain further information for controlling the motor such as a signal to indicate rotational direction. A second or additional tracks could also be included for a more sophisticated motor control system. Finally, it is possible to develop the track and the control signals on it into an incremental encoder for motor control purposes.

It is also not imperative that two separate recording and/or sensing heads be provided for the control signals and data signals, nor that the control signals be located on a concentric track. Rather, it is obvious to the expert that a single recording/sensing head can be made to seek out the relevant track at the right time, or that, in the recording of data, the control signals for the motor can also be recorded in accordance with any other data formatting process at another location and in a different arrangement.

It should also be pointed out that, in the case of a storage unit, the data flow of which is controlled and/or evaluated by a microcomputer, the function of the switch assembly required for realisation of the inventive concept is most expediently performed by the microcomputer of the storage unit, so that a further reduction in cost results.

It will be appreciated that the invention is not restricted to the particular details described above with reference to the drawings and that numerous modifications or variations can be made without departing from the invention as claimed in the following claims. Further, each individual feature described above can be separately incorporated in rotary drives in general.

CLAIMS

1. A rotary drive for a data storage medium, which drive comprises: a brushless direct current motor with a permanently magnetic rotor and a wound stator having a winding comprising one or more winding coils; a switch arrangment for activating the winding to generate a magnetic field producing rotary movement in the rotor, and a sensing device for reading signals recorded on the data storage medium and having an output connected to the switch arrangement for activation of the winding, wherein the said signals comprise control signals which identify at least those angular positions of the rotor, with respect to the stator, at which the power supply to the winding has to be switched.

2. A drive as claimed in Claim 1, wherein the control signals comprise first and second control signals for each said angular position of the rotor, and the switch arrangement can be induced to activate the winding by a first control signal to interrupt the power supply to the winding coil(s) currently being energized, and by a subsequent second control signal to switch the power supply through to the next of the winding coil(s) in the energizing sequence.

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3. A drive as claimed in Claim 1, wherein, on receipt of a control signal supplied by the sensing device, the switch arrangement for activating the winding interrupts the power supply to the energized winding coil(s), a delay device in the switch arrangement is activated and, on expiry of a delay time, the power supply is switched through to the next of the winding coil(s) in the energizing sequence.

4. A drive as claimed in Claim 1, wherein at least two spaced control signals for each said angular position of the rotor are arranged in a circumferential direction on the data storage medium, and wherein the switch arrangement comprises a measuring device to determine the chronological interval between the two control signals which follow each other as the data storage medium rotates, the measurement result of which measuring device is evaluated to control the current amplitude or the number of current pulses to be supplied to the winding.

5. A drive as claimed in Claim 4, wherein the switch arrangement includes a comparator to determine the deviation of the said chronological interval from a predetermined setpoint, and a delay device with varying or variable delay times, and wherein a delay time of a magnitude commensurate with the deviation from the setpoint can be initiated by the switch arrangement

between the interruption of the power supply to the currently energized winding coil(s) and energization of the next of the winding coil(s) in the energizing sequence.

6. A drive as claimed in Claim 4, wherein the switch arrangement includes a comparator to determine the deviation of the said chronological interval from a predetermined setpoint, and wherein, in accordance with the deviation from the setpoint, the switch arrangement switches through a greater or smaller current pulse to the next of the winding coil(s) in the energizing sequence.

7. A drive as claimed in any one of the preceding claims, wherein the sensing device comprises a separate write (record) and/or read (sensing) head for the motor control signals and for the data signals to be written onto or read from the data storage medium.

8. A drive as claimed in any one of the preceding claims, wherein the control signals are located on a concentric storage track of the data storage medium.

9. A drive as claimed in Claim 8, wherein the storage track is a radially outer track of the data storage medium.

10. A drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 1.

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11. A drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figures 2 and 3.

12. A drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figures 4 and 5.

13. A drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figures 6 and 7.