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(54) **Spindle motor control arrangement**

(57) A spindle motor has a rotor (1a, Fig 1); a magnetic disk (3) disposed on the outer periphery of the rotor; a multiphase motor coil L1-L4 supplying rotation power to the rotor following excitation by drive current; a power supply 7, 8 which supplies the drive current to the motor coil in phase; a rotation monitor (10, Fig 4) which monitors the state of rotation of the rotor and outputs monitoring signals; a controller (11) which outputs control signals according to the monitoring signal; and a phase adjuster 9, Q1-Q4 which supplies drive current from the power supply to the motor coil in a specified number of phases according to the control signal. The motor is therefore started at high torque by energising 2 phase coils at a time and then switched to a lower torque by energising the coils one phase at a time once the motor speed has reached a specified value (eg half the target value). The coils may be energised two phases at a time for a time determined by a timer at the controller 11 after which they are energised one phase at a time.

FIG.3

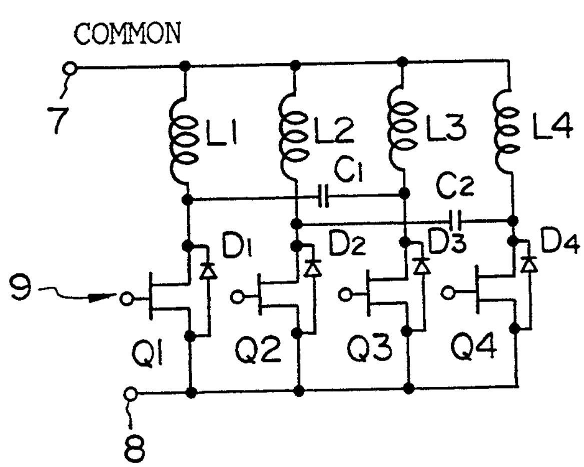

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FIG.1

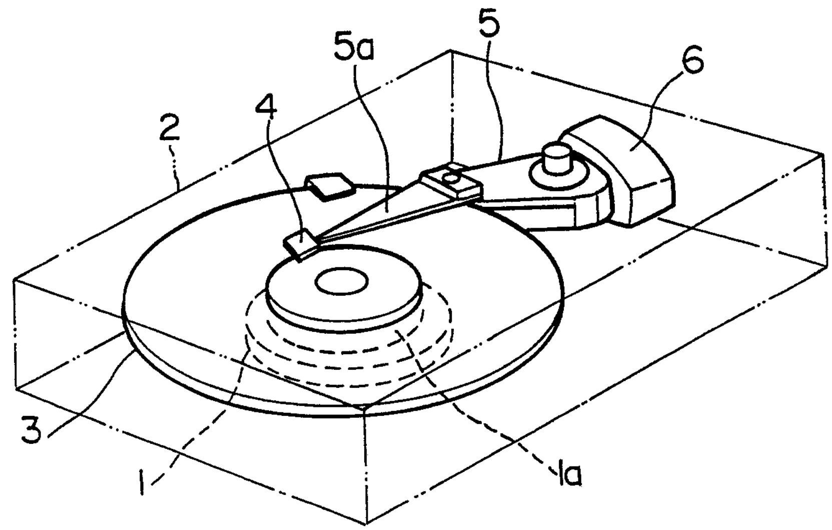


FIG.2

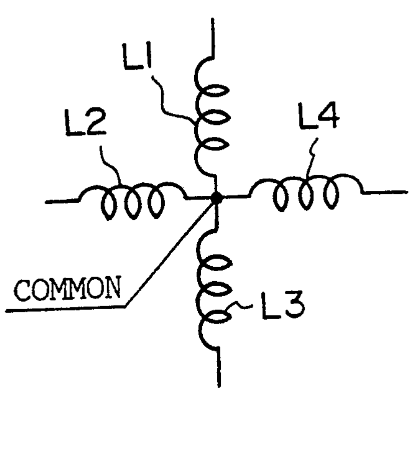


FIG.3

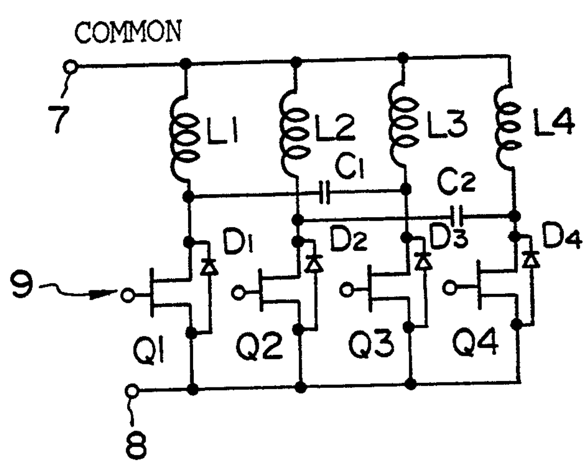


FIG.4

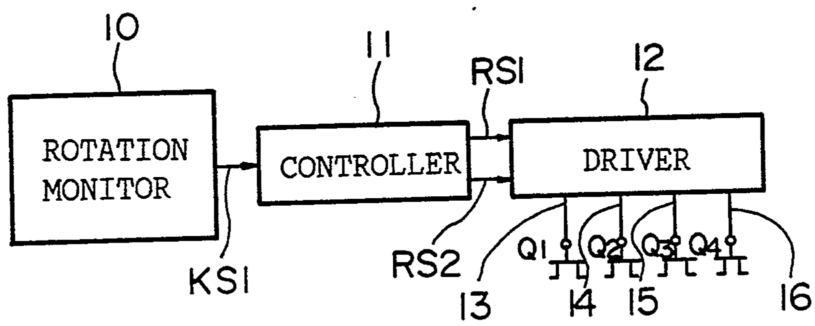
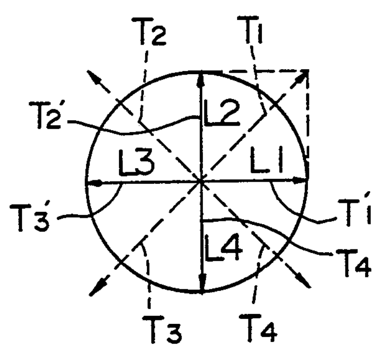

10
11
RSI
12
ROTATION
MONITOR
CONTROLLER
DRIVER
KSI
RS2
Q1
Q2
Q3
Q4
13
14
15
16

FIG.5


T2
T1
T2'
L2
L3
L1
T3'
T1'
L4
T4
T3
T4

SPINDLE MOTOR

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a spindle motor which may be used in, for example, a magnetic disk unit.

Prior Art

With the emergence of more compact magnetic disk units, more compact spindle motors have been needed. The system for obtaining a specified number of revolutions in these spindle motors is used in which several motor coils are excited one phase at a time. This system may be used in a spindle motor to drive disks in a magnetic disk unit.

Unfortunately, when a spindle motor is made compact, the torque of the spindle motor is reduced, and occasional incorrect revolution (or no revolution at all) is produced at start up when revolution force is applied.

SUMMARY OF THE INVENTION

The purpose of this invention is to provide a spindle motor which reliably produces correct revolution at start-up.

The spindle motor of this invention consists of a rotor; a magnetic disk disposed on the outer periphery of the rotor; a multiphase motor coil supplying rotation power to the rotor following excitation by drive current; a power supply which supplies the drive current to the motor coil in phase; a rotation monitor which monitors the state of rotation of the above rotor and outputs monitoring signals; a controller which outputs control signals according to the rotation monitoring signal; and a phase adjuster which supplies drive current from the power supply to the motor coil in a specified number of phases according to the control signals.

When the rotational-state monitor detects a state of rotation, it outputs a monitoring signal and then outputs a control signal from the controller.

The number of control-specified phases is adjusted by the unit which supplies the drive current (supplied from the power supply) to the motor coil.

In this manner, the spindle motor of the present invention supplies the drive current to the motor coil in a specified number of phases, depending on the state of rotation of the rotor.

For example, when the rotor starts, drive current is supplied to the two-phase motor coil, and a large torque is generated to meet the requirement for the large load. Also, when the rotor attains a specified speed, the drive current can be supplied to the single phase motor coil to save power.

Thus, even if the size of the spindle motor is altered, improper revolution at start-up can be prevented.

In addition, the rotor of this spindle motor rapidly reaches the specified speed and thus reduces access time.

BRIEF DESCRIPTIONS OF THE DRAWINGS

Fig. 1 shows a magnetic disk unit and the construction of the magnetic disk unit including the spindle motor.

Fig. 2 is a circuit diagram which shows the circuit configuration of the spindle motor.

Fig. 3 is a circuit diagram which shows the circuit configuration of the spindle motor and the controller.

Fig. 4 is a functional block diagram which shows the controller of the spindle motor.

Fig. 5 is a vector diagram which shows the rotary torque at the rotor.

DETAILED DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

The following is a description of embodiments of the present invention with reference to the drawings.

In Fig. 1, 1 is the spindle motor. This spindle motor 1 is within the main unit of the magnetic disk unit 2. The spindle motor 1 has the rotor 1a which is supported on a stator (not shown in figure) such that it can rotate freely. The rotor 1a has a magnet (not shown in the figure). The magnetic disk 3 is located on the outer periphery of the rotor 1a. The magnetic disk 3 rotates when the rotor 1a rotates.

Additionally, 4 indicates the head which writes data and subsequently reads it from the magnetic disk 3. This head 4 is mounted on the gimbal 5a at the tip of the carrier 5. A driving mechanism 6 with a voice coil motor is located on the rear part of the carrier 5. The carrier 5 moves the magnetic disk 3 in the direction of the radius by means of the driving mechanism 6.

Figs. 2 and 3 show the circuit configuration of the above spindle motor 1. As shown in Fig. 2, the spindle motor 1 is a unipolar-type, 4-phase spindle motor in which four motor coils L1 - L4 are connected.

Drive current is supplied to the L1 - L4 motor coils by the power supply (not shown in the figure) which is connected to terminals 7 and 8. Also, the phase adjuster 9, which turns the drive current supply on or off, is connected to the L1 - L4 motor coils. The phase adjuster 9 consists of the Q1 - Q4 FETs (Field Effect Transistors) as switching elements. The D1 - D4 diodes are connected to the Q1 - Q4 FETs to prevent inverse current flow. Also, the capacitors C1 and C2 absorb power surges generated from the L1 - L4 motor coils; the C1 capacitor is connected to the L1 and L3 motor coils, and the C2 capacitor is connected to the L2 and L4 motor coils.

In Fig. 4, 10 is the rotation monitor. This rotation monitor 10 monitors the rotation state of the rotor 1a and outputs the KS1 monitoring signal. As this rotation monitor 10 monitors, a pulse signal detector, which detects pulse signals from the L1 - L4 motor coils, allows the rotor 1a to rotate. Also, as the rotation monitor 10 monitors, a detection sensor which monitors the state of rotation and is based on servo signals indicate the rotational angle written into the magnetic disk 3, can be used.

The symbol 11 indicates the controller. The controller 11 outputs the phase excited signal RS1 and 2-phase excited signal RS2 to the drive 12 depending on the monitoring signal KS1 and allows the monitoring signal KS1 from the rotation monitor 10 to be input.

The drive 12 and FETs Q1 - Q4 are connected by the control lines 13, 14, 15 and 16. The drive 12 outputs control current to the FETs Q1 - Q4 by allowing the input of the 1-phase excitation signal RS1 or 2-phase excitation signal RS2 output from the controller 11.

The following describes the operation of the spindle motor 1 in the above configuration:

(1) At start-up, the rotation monitor 10 senses that the rotor 1a of the spindle motor 1 has stopped and the rotation monitor 10 will then output the monitoring signal KS1.

(2) When the monitoring signal KS1 is input to the controller 11, the controller 11 outputs the 2-phase excited signal RS2, depending on the monitoring signal KS1.

(3) When the 2-phase excited signal RS2 is input to the drive 12, control current is supplied to the FETs Q1 and Q2 from the drive 12 through the control lines 13 and 14.

(4) The FETs Q1 and Q2 turn on when the control current is input. Then, the drive current supplied from the power supply flows into the motor coils L1 and L2 through the FETs Q1 and Q2, thus exciting the motor coils L1 and L2.

(5) After this, the control current is supplied to the FETs Q2 and Q3 from the drive 12 through the control lines 14 and 15. Then, the drive current flows to the motor coils L2 and L3 through the FETs Q2 and Q3, thus exciting the motor coils L2 and L3.

(6) Subsequently, the control current is supplied to the FETs Q3 and Q4 from the drive 12 through the control lines 15 and 16. Then, the drive current flows to the motor coils L3 and L4 through the FETs Q3 and Q4, thus exciting the motor coils L3 and L4.

(7) Subsequently, the control current is supplied to the FETs Q4 and Q1 from the drive 12 through the control lines 16 and 13. Then, the drive current flows to the motor coils L4 and L1 through the FETs Q4 and Q1, and exciting the motor coils L4 and L1.

(8) Steps (3) - (7) are repeated.

That is, control signals are supplied to the FET Q1 - Q4 in the order of Q1, Q2; Q2, Q3; Q3, Q4; Q4, Q1; ... and the motor coils L1 - L4 are excited in the order of L1, L2; L2, L3; L3, L4; L4, L1; ... Thus, the rotor 1a of the spindle motor generates a high torque prior to the initiation of rotation.

(9) The controller 11 confirms that the rotor 1a speed has reached the specified speed (for example, approximately 1/2 the target speed, depending on the monitoring signal from the rotation monitor, and then outputs the 1-phase excitation signal RS1.

(10) When the 1-phase excitation signal RS1 is input, the drive 12 supplies control current to the FETs Q1 - Q4 through the control lines 13 - 16 sequentially.

That is, the control signal is supplied to the FETs Q1 - Q4 in the order of Q1, Q2, Q3, Q4, Q1 ...

(11) The FETs Q1, Q2, Q3 and Q4 are turned on and off sequentially. Drive current supplied from the power supply is supplied to the motor coils L1 - L4 in the order of L1, L2, L3, L4, L1, ... Then, the motor coils L1 - L4 are excited in the order of L1, L2, L3, L4, L1, ... and the rotor 1a continues to rotate.

As Fig. 5 shows, the torque value of the rotor 1a, when the motor coils L1 - L4 are excited two phases at a time, becomes T1' - T4' (approximately 1.4 times larger than the torque values T1 - T4 which are obtained by combining the torque values T1 - T4 of the rotor 1a when the motor coils L1 - L4 are excited one phase at a time.

When the above spindle motor 1 starts, the motor coils L1 - L4 are excited two phases at a time, the rotor 1a rotates and excites the motor coils L1 - L4 one phase at a time after the specified speed of the rotor 1a is reached.

That is, when the rotor 1a starts, it excites the motor coils L1 - L4 two phases at a time and achieves revolution at a high torque value. Also, the rotor 1a excites the motor coils L1 - L4 one phase at a time, and saves power during revolution.

In addition, the rotation monitor 10 can detect if the speed of the rotor 1a is 0 rpm. If this is true, the rotation monitor 10 will then output a monitoring signal.

Furthermore, the rotation monitor 10 can act as an acceleration sensor which detects the angular acceleration of the rotor 1a. If there is friction or adhesion (caused by, for example, solvents on the magnetic disk 3 surface) between the magnetic disk 3 and the head 4, the acceleration sensor detects that the negative angular acceleration exceeds a specified value, and then outputs a monitoring signal KS1 when the rotor 1a cannot be started, even if high load is applied, and the motor coils L1 - L4 are excited, one phase at a time. Then, the controller 11 outputs the 2-phase excitation signal RS2 based on the monitoring signal KS1 and excites the motor coils L1 -L4, two phases at a time. Thus, the rotor 1a rotates at high torque and is therefore able to start.

In this manner, the motor coils L1 - L4 are excited, two phases at a time and are thereby started at high torque, in the case where the motor coils L1 - L4 cannot be started if the rotor 1a excites the motor coils L1 - L4 one phase at a time. Then, after the rotor 1a starts, the motor coils L1 - L4 are excited one phase at a time, resulting in the rotation of the rotor 1a, thus enabling the rotor 1a to rotate without any improper revolution, and rotating the magnetic disk positively. Power consumption can thereby be further reduced.

The motor coils L1 - L4 may be excited one phase at a time, after a time lapse, by providing a time gauge as a timer at the controller 11 and exciting the motor coils L1 - L4, two phases at a time, to rotate at a high torque value.

In this case, the controller 11 outputs the 2-phase excitation signal RS2 to the drive 12 at the starting of the rotor 1a. Based on this 2-phase excitation signal RS2, the drive 12 supplies control current to the FETs Q1 - Q4, two FETs at a time. Thus, as in the above embodiment, when starting the rotor 1a, the motor coils L1 - L4 are excited in sequence, two phases at a time, and the rotor 1a rotates at high torque. Then, the time gauge measures the time between the rotor 1a start and the output lapse signal which notifies the controller 11 of the interval. With this, the controller 11 outputs the 1-phase excitation signal RS1 to the drive 12 and control current is supplied sequentially to the FETs Q1 - Q4 from the drive 12. Thus, the motor coils L1 - L4 are excited sequentially, one phase at a time, and the rotor 1a of the spindle motor 1 continues to rotate.

Although the motor coil L1 - L4 of the spindle motor 1 in the above embodiment is a 4-phase type, the number of motor coil phases is not limited to that in the above embodiment.

CLAIMS

1. A spindle motor comprising:

a rotor;

a magnetic disk disposed on the outer periphery of the rotor;

a multiphase motor coil supplying rotation power to the rotor following excitation by drive current;

a power supply which supplies the drive current to the motor coil in phase;

a rotation monitor which monitors the state of rotation of the rotor and outputs monitoring signals;

a controller which outputs control signals according to the monitoring signal; and

a phase adjuster which supplies drive current from the power supply to the motor coil in a specified number of phases according to the control signal.

2. A spindle motor according to claim 1, wherein said motor coil comprises 4 motor coils.

3. A spindle motor according to claim 1 or 2, wherein said motor coil comprises a capacitor to absorb power surge.

4. A spindle motor according to any preceding claim wherein said rotation monitor comprises a detection sensor to detect revolution of the rotor.

5. A spindle motor according to claim 4, wherein said detection sensor outputs a monitoring signal when the revolution speed of the rotor is detected to have attained a specified value.

6. A spindle motor according to claim 4 or 5, wherein said detection sensor outputs a monitoring signal when the revolution speed of the rotor is detected to be 0 revolutions per minute.

7. A spindle motor according to any preceding claim, wherein said rotation monitor comprises an acceleration sensor to measure the angular acceleration of the rotor.

8. A spindle motor according to any preceding claim, wherein said rotation monitor comprises a pulse signal detector to detect the pulse signal from the motor coil.

9. A spindle motor according to any preceding claim, wherein said magnetic disk has a servo signal.

10. A spindle motor according to claim 9, wherein said servo signal indicates the rotational angle.

11. A spindle motor according to claim 9 or 10, wherein said rotation monitor detects servo signals from the magnetic disk.

12. A spindle motor according to any preceding claim, wherein said controller comprises a control circuit for outputting control signals according to monitoring signals, and a driver to output control current according to the control signal.

13. A spindle motor according to any preceding claim, wherein said controller outputs a 2-phase excitation signal, according to the monitoring signal, to excite the motor coil two phases at a time at the initiation of rotor rotation.

14. A spindle motor according to any preceding claim, wherein said phase-adjuster comprises an on/off switch for controlling the supply of drive current from the power supply unit to the motor coil.

15. A spindle motor according to claim 14, wherein said on/off switch comprises switching elements.

16. A spindle motor according to claim 15, wherein said switching elements comprise Field Effect Transistors.

17. A spindle motor according to claim 15 or 16, wherein said switching elements include a diode for preventing inverse current.

18. A spindle motor comprising:

a rotor;

a magnetic disk disposed on the outer periphery of the rotor;

a multiphase motor coil supplying rotation power to the rotor following excitation by drive current;

a power supply which supplies the drive current to the motor coil in phase;

a time gauge to output a lapse signal after a specified interval elapses following the initiation of rotation of the rotor;

a controller to output a 2-phase excitation signal to excite the motor coil two phases at a time following no input of a lapse signal, and to output a 1-phase excitation signal to excite the motor coil one phase at a time following the input of a lapse signal; and a phase-adjuster to supply drive current from the power supply to the 2-phase motor coil by the input of a 2-phase excitation signal, and said phase-adjuster to supply drive current from the power supply unit to the 1-phase motor coil by input of a 1-phase excitation signal.

19. A spindle motor according to claim 18, wherein said time-gauge comprises a timer.

20. A spindle motor substantially as herein described with reference to and as shown in the accompanying drawings.

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