

DISK DRIVE WITH IMPROVED SHOCK SENSING

TECHNICAL FIELD

This invention relates to data recording disk drives, and more particularly to magnetic recording disk drives that use shock or vibration sensing to modify certain drive operations.

BACKGROUND OF THE INVENTION

Disk drives, also called disk files, are information storage devices that use a disk mounted on a spindle for rotation about an axis, and having concentric tracks containing the information, a head or transducer for reading and/or writing data onto the various tracks, and an actuator connected to a carrier for the head for moving the head to the desired track and maintaining it over the track centerline during read and write operations. The most common form of actuator is a rotary voice coil motor (VCM) actuator that moves the head carrier in a generally arcuate path across the disk. There are typically a number of disks mounted

on the spindle for rotation by a disk drive motor, and a number of head carriers connected to the actuator for accessing the surfaces of the disks. A baseplate (or base casting) precisely supports the spindle, and head actuator. In conventional magnetic recording disk drives, the head carrier is an air-bearing slider that rides on a bearing of air above the disk surface when the disk is rotating at its operational speed. The slider is maintained next to the disk surface by a biasing force from a suspension that connects the slider to the actuator.

Disk drives are sensitive to external shock and vibration that can cause the heads to move to the wrong track during a track accessing or "seek" operation or to move off track during a read or write operation. The writing of data on the wrong track is unacceptable because it usually results in the loss of data on the track that is written over. Various techniques have been proposed to address this problem by sensing the external force and either compensating for it or by shutting down some operation of the disk drive until the force is removed. These techniques typically involve the use on an accelerometer or shock sensor mounted in the disk drive. An example of a disk drive with acceleration rate sensing is the assignee's U.S. Pat. No. 5,521,772, which describes that the sensing may be used to

inhibit the writing of data, to provide feedback of the sensing to the actuator tracking control or servo system to compensate to shock or vibration-induced tracking errors, or to move the heads to a parking zone.

These sensors are commonly mounted on the drive's electronics card or printed circuit board to keep the lead lengths as short as possible and decrease the sensor's susceptibility to electrical noise. The cards themselves are commonly mounted so that a gap exists between the card and baseplate. This gap allows components to be mounted on the gap side of the card and permits an air space for cooling.

The typical printed circuit board, however, is flexible in the direction perpendicular to the plane of the board. Thus, when a shock sensor is mounted on the card, any flexibility in the card can cause delays between the occurrence of a shock to the baseplate and the time at which it is detected. The flexibility of the card can also increase or decrease the amplitude of the shock as seen at the sensor, leading to false or missing detections.

Typically, the major concern of such shock systems has been shock occurring in a direction that would cause the actuator to rotate. However, as the track density (i.e., number of data

tracks per radial inch) of disk drives has increased, other effects of external shock has become more pronounced. This is because the distance moved for a given shock may be the same, but at the higher track density, the offtrack movement becomes a larger percentage of the track pitch. Specifically, shock in the direction of the axis of rotation of the disk drive spindle causes the baseplate of the drive to distort slightly, with the result that the spindle and actuator move out of angular alignment and the heads are moved offtrack.

The printed circuit board on which the shock detector is mounted is generally positioned in a plane perpendicular to the direction of the axis of rotation of the disk drive spindle. Thus, the flexibility of the card in the direction perpendicular to the plane of the card makes the shock sensor least sensitive to shocks in the direction of the axis of rotation of the disk drive spindle.

What is needed is the ability to insure that any shock to the drive is sensed by the shock sensor immediately and reliably. This need is especially important in the direction perpendicular to the plane of the printed circuit board and in the direction of the axis of rotation of the disk drive spindle.

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SUMMARY OF THE INVENTION

The present invention is a data recording disk drive having a shock sensor for detecting acceleration, mechanically supported by and electrically connected to circuitry on a printed circuit board, at least a portion of the electronic circuitry for operating the disk drive, wherein the baseplate, which supports the drive spindle, actuator and printed circuit board, includes a support member on the side of the printed circuit board opposite the shock sensor, and positioned to support the printed circuit board directly opposite the shock sensor. The baseplate support member and printed circuit board are arranged to have an interference fit therebetween so that the printed circuit board is placed under stress so as to transmit any shock force between the baseplate and the shock sensor. The interference fit may be by means of a support layer provided on the printed circuit board facing the support member, or may be by having the baseplate support member extend into the plane of the printed circuit board in the Z direction. The printed circuit board has a flexural mode in the Z direction, and the interference fit is sufficient to eliminate the flexural mode in the Z direction, which may be the direction of the axis of rotation of the drive spindle.



BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cut away top view of a magnetic data recording disk drive in which the present invention may be incorporated;

FIG. 2 is a diagrammatical illustration of a printed circuit board for the disk drive of FIG. 1;

FIG. 3 is a perspective view of a baseplate or base casting for the disk drive of FIG. 1 which incorporates the present invention;

FIG. 4 is a cross sectional view of the printed circuit board of FIG. 2 and of the baseplate of FIG. 3, illustrating the present invention;

FIG. 5 is a graphical representation of a shock impact to the disk drive measured at the baseplate and at the shock sensor arranged without the present invention; and

FIG. 6 is a graphical representation of a shock impact to the disk drive measured at the baseplate and at the shock sensor arranged with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A disk drive capable of incorporating the present invention is shown in a partially cut away diagrammatic top view in FIG. 1.

A magnetic recording disk 10, having "top" and "bottom" surfaces, is supported on a spindle 6 and rotated by the drive or spindle motor (not shown). The magnetic recording on each disk surface is in the form of an annular pattern of concentric data tracks (not shown).

A head carrier 13 is positioned on the top surface of disk 10. Carrier 13 is an air-bearing slider having an air-bearing surface facing toward the disk. The head carrier 13 supports a read/write transducer on its trailing end for reading and writing data to the magnetic media on the disk surface. The transducer may be an inductive read/write head or a dual element head having an inductive write element and a magnetoresistive read element. Carrier 13 is attached to an actuator arm 14 by means of a suspension 15. The suspension 15 provides a slight spring force that biases the carrier 13 toward the disk surface. A second carrier, also supporting a read/write transducer, is positioned on the bottom surface of disk 10 and is attached to an actuator arm by means of a suspension.

Actuator arms 14 are attached to a rotary actuator 27. The actuator is typically a rotary voice coil motor (VCM) that comprises a coil movable within a fixed magnetic field, the direction and velocity of the coil movements being controlled by motor current signals supplied by a microcontroller. As the disk 10 rotates, the rotary actuator 27 moves the carriers 13 in a generally arcuate path radially in and out over their respective disk surfaces so that the read/write transducers may access different portions of the disk surfaces where data is desired to be read or recorded. Both the actuator 27 and spindle 6 are mounted to a baseplate 9.

In this conventional type of air-bearing disk drive, the rotation of the disk 10 generates an air bearing between the carrier 13 and its associated disk surface. During operation of the disk drive, the air bearing thus counterbalances the slight spring force of the suspension 15 and supports the carrier 13 off and slightly away from the disk surface 11 by a small, substantially constant spacing. The present invention is also applicable to other types of disk drives, however, such as contact or near-contact recording disk drives, where the head carrier is urged into contact with the disk during read and write operations.

The various components of the disk drive are controlled in operation by control signals generated by the microcontroller. Typically, the microcontroller comprises logic control circuits, memory storage, and a microprocessor, for example. The microcontroller generates control signals for various drive operations, such as spindle motor control signals and track following and seek control signals for actuator 27.

Data from the surface of disk 10 is read by the read/write head on slider 13 and sent on cable 30 to read/write channel circuitry. Write signals are sent on cable 30 from the read/write channel circuitry to the head for writing on the disk. Similarly, the read/write head reads head position servo information recorded on the disk, typically at equally angularly spaced servo sectors embedded between data sectors. The servo information is also sent over cable 30 to servo circuitry for demodulation and conversion to track position signals. Typically, the track position signals are employed by servo control circuitry to control the actuator 27 to pivot the arms 14 radially inward and outward to move and position the carriers 13 to the desired track and to maintain track following of the desired track on the corresponding surface of disk 10.

Usually, the circuitry described above is located on a printed circuit board, such as that illustrated in FIG. 2. The "printed circuit board", also called "electronics card" is defined as any suitable support for electronic components and interconnecting leads. Examples of circuit components 34, are shown in phantom, and may be located on the top or bottom of printed circuit board 22. In many modern high capacity disk drives, a shock sensor 50 is located on the printed circuit board to keep the lead lengths as short as possible and decrease the sensor's susceptibility to electrical noise. Many examples of shock sensors are in the prior art, and the present invention is usable with any of the typical shock sensors. One example that may be used is that of assignee's '772 patent. The shock sensor used most advantageously with the subject invention will provide shock detection signals in the X, Y and Z directions.

The shock detection signals are used to generate a write inhibit signal to the read/write channel circuitry when the signals exceed a predetermined threshold. In addition, the shock detection signals may be used to alter the control to the actuator 27, either to reposition the heads in closer proximity to the desired data tracks, or upon exceeding a threshold, to move the heads to a parking zone.

The printed circuit board has mounting holes 24, 25, 26, and may have several more spaced about the board. The mounting holes are provided for mounting the printed circuit board on the drive baseplate and/or housing.

The baseplate 9 is shown in FIG. 3. As is typical, screw holes 60 are provided in mounting pads 70, 72 and 74 for screws for mounting the printed circuit board 22 of FIG. 2. The mounting pads are all in the same plane, often machined to be level. Also typical are holes 62 and 64 for mounting opposite ends of spindle 6, and holes 66 and 68 for mounting opposite ends of actuator 27 of FIG. 1. In the usual case, baseplate 9 is an aluminum casting with certain machined surfaces and holes for precisely positioning various components. As defined hereby, "baseplate" refers to any suitable base for a disk drive, including, but not limited to cast, molded, forged or machined metal, ceramic or other suitable material for mounting a disk drive spindle and actuator.

Referring additionally to FIG. 4, which is a cross sectional view of the printed circuit board of FIG. 2 and of the baseplate of FIG. 3, the board 22 is mounted so that a gap exists between the board and baseplate 9. This gap allows electrical

interconnections and/or components to be mounted on the gap side of the card and permits an air space for cooling.

The typical printed circuit board is flexible in the Z direction, perpendicular to the plane of the board. Thus, when shock sensor 50 is mounted on the board, the flexibility in the card can cause delays between the occurrence of a shock to the baseplate and the time at which it is detected. The flexibility of the board can also increase or decrease the amplitude of the shock as seen at the sensor.

As is usual, the printed circuit board on which the shock detector is mounted is positioned in the X, Y plane, perpendicular to the direction of the axis of rotation of the disk drive spindle. Thus, the flexibility of the card in the Z direction makes the shock sensor least sensitive to shocks in the direction of the axis of rotation of the disk drive spindle.

A raised pad or support member 80 is provided on baseplate 9, on the side of the printed circuit board 22 opposite the shock sensor 50, and positioned to support the printed circuit board directly opposite the shock sensor. The support from the raised pad provides a direct structural link between the sensor and the baseplate. The raised pad may be of any size, but preferably only needs to be of approximately the same area as the shock

sensor, so the impact on component mounting space and cooling is minimal.

The raised pad or baseplate support member and printed circuit board are arranged to have an interference fit therebetween so that the printed circuit board is placed under stress so as to transmit any shock force between the baseplate and the shock sensor. The interference fit may be by means of a support layer provided on the printed circuit board facing the support member, or may be by having the baseplate support member extend into the plane of the printed circuit board in the Z direction. Another alternative is to provide a shim between the baseplate support member and printed circuit board, bonded to or attached to the support member or printed circuit board. As described above, the printed circuit board has a flexural mode in the Z direction, and the interference fit is sufficient to eliminate the flexural mode in the Z direction, the direction of the axis of rotation of the drive spindle.

To ensure that the printed circuit board does not slap against the baseplate at the raised pad, the pad 80 is positioned closely adjacent one of the mounting pads 72. Screw 78 is mounted in hole 60 in the mounting pad to secure the board to the

baseplate and prevent any flexure or movement which might result in the board losing contact with the pad 80.

The raised pad or support member 80 positioned as described, insures that any shock to the drive is sensed by the shock sensor 50 immediately and reliably. FIGS. 5 and 6 provide an illustration of the effectiveness of the present invention. FIG. 5 is a graphical representation of a shock impact to the disk drive measured at the baseplate and at the shock sensor arranged without the present invention. As illustrated, the shock measured at the shock sensor is of significantly reduced amplitude and delayed from that measured at the baseplate. The signals provided by the shock sensor to the drive may not meet the desired threshold or may be delayed and not prevent the head from writing offtrack. FIG. 6 is a graphical representation of a shock impact to the disk drive measured at the baseplate and at the shock sensor arranged with the present invention, and is similar in both amplitude and timing.

While the preferred embodiments of the present invention have been illustrated in detail, it should be apparent that modifications and improvements may be made to the invention without departing from the spirit and scope of the invention as described in the following claims.



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CLAIMS

1. In a data recording disk drive having:
 - at least one data disk having tracks on at least one surface thereof for the recording of data and said data disk supported by a spindle for rotation;
 - a motor connected to said spindle for rotating said disk;
 - at least one transducer for reading data from or writing data to said tracks for each said surface of said disk;
 - at least one carrier for supporting a transducer near the surface of the disk;
 - an actuator connected to said carrier for moving the carrier and supported transducer across said tracks of the disk and for maintaining the transducer on a desired track; and
 - electronic circuitry for operating said motor, actuator and transducer;
- the improvement comprising:
 - a shock sensor for detecting acceleration;
 - a printed circuit board mechanically supporting said shock sensor and having at least a portion of said electronic

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circuitry, said electronic circuitry electrically connected to said shock sensor; and

a baseplate supporting said spindle, said actuator and said printed circuit board, said baseplate having a support member for said printed circuit board directly opposite said supported shock sensor, said baseplate support member and said printed circuit board having an interference fit; whereby said printed circuit board is placed under stress so as to transmit any shock force between said baseplate and said shock sensor.

2. The improved data recording disk drive of Claim 1, wherein:

said baseplate additionally comprises mount members for mounting said printed circuit board thereon, and said mount members and said support member comprising a common plane for mounting and supporting said printed circuit board; and

said printed circuit board additionally comprises a support layer thereon facing said support member for providing said interference fit therebetween.

3. The improved data recording disk drive of Claim 2, wherein:

said common plane of said baseplate is perpendicular to the axis of rotation of said spindle.

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4. The improved data recording disk drive of Claim 3, wherein:
said printed circuit board has a flexural mode, and said interference fit between said printed circuit board and said baseplate support member is sufficient to eliminate said flexural mode in the direction of said axis of rotation of said spindle.
5. The improved data recording disk drive of Claim 4, wherein:
one of said mount members of said baseplate is located closely adjacent but spaced from said baseplate support member.
6. The improved data recording disk drive of Claim 5, wherein:
a mounting screw mounts said printed circuit board to said closely adjacent mount member.
7. The improved data recording disk drive of Claim 1, wherein:
said printed circuit board is in a plane perpendicular to the axis of rotation of said spindle; said printed circuit board has a flexural mode; and said interference fit between said printed circuit board and said baseplate support member is sufficient to eliminate said flexural mode in the direction of said axis of rotation of said spindle.



8. The improved data recording disk drive of Claim 7, wherein:
said baseplate additionally comprises mount members for mounting said printed circuit board thereon, and one of said mount members is located closely adjacent but spaced from said baseplate support member.

9. The improved data recording disk drive of Claim 8, wherein:
a mounting screw mounts said printed circuit board to said closely adjacent mount member.



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10. A data recording disk drive comprising:

at least one data disk having tracks on at least one surface thereof for the recording of data and said data disk supported by a spindle for rotation, said spindle axis comprising the Z direction;

a motor connected to said spindle for rotating said disk;

at least one transducer for reading data from or writing data to said tracks for each said surface of said disk;

at least one carrier for supporting a transducer near the surface of the disk;

an actuator connected to said carrier for moving the carrier and supported transducer across said tracks of the disk and for maintaining the transducer on a desired track; and

electronic circuitry for operating said motor, actuator and transducer;

a shock sensor for detecting acceleration in at least said Z direction;

a printed circuit board mechanically supporting said shock sensor and having at least a portion of said electronic circuitry, said electronic circuitry electrically connected to said shock sensor; and





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a baseplate supporting said spindle, said actuator and said printed circuit board, said baseplate having a support member for said printed circuit board directly opposite said supported shock sensor, said baseplate support member and said printed circuit board having an interference fit; whereby said printed circuit board is placed under stress so as to transmit any shock acceleration in the Z direction between said baseplate and said shock sensor.

11. The data recording disk drive of Claim 10, wherein:

said baseplate additionally comprises mount members for mounting said printed circuit board thereon, and said mount members and said support member comprising a common plane for mounting and supporting said printed circuit board, said common plane being perpendicular to said Z direction; and

said printed circuit board additionally comprises a support layer thereon facing said support member for providing said interference fit therebetween.

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12. The data recording disk drive of Claim 11, wherein:
said printed circuit board has a flexural mode, and said interference fit between said printed circuit board and said baseplate support member is sufficient to eliminate said flexural mode in said Z direction.
13. The data recording disk drive of Claim 12, wherein:
one of said mount members of said baseplate is located closely adjacent but spaced from said baseplate support member.
14. The data recording disk drive of Claim 13, wherein:
a mounting screw mounts said printed circuit board to said closely adjacent mount member.



15. The data recording disk drive of Claim 10, wherein:

said printed circuit board is in a plane perpendicular to said Z direction; said printed circuit board has a flexural mode; and said baseplate support member extends into said printed circuit board plane in the Z direction so as to cause said interference fit between said printed circuit board and said baseplate support member; whereby said interference fit is sufficient to eliminate said flexural mode in the direction of said axis of rotation of said spindle.

16. The data recording disk drive of Claim 15, wherein:

said baseplate additionally comprises mount members for mounting said printed circuit board thereon, and one of said mount members is located closely adjacent but spaced from said baseplate support member.

17. The improved data recording disk drive of Claim 16, wherein:

a mounting screw mounts said printed circuit board to said closely adjacent mount member.