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SERVO METHOD AND DEVICE FOR HARD DISK DRIVE

Field of the Invention

The present invention relates to a servo method and device for a hard disk drive head, and, in particular, to a servo method and device for a hard disk drive head for positioning the head of the hard disk drive which stores and reproduces information.

Background of the Invention

Hard disk drive units (referred to as HDDs below) have been put to practical use as information-storing media for recording the massive amounts of information used in computers. In these HDDs, which include a plurality of magnetic recording disks (referred to as disks below), a reproduction and recording head (referred to as a magnetic head below) is positioned on the desired track established on this disk to store information on the disk and to reproduce information from the disk.

The capacity of HDDs has recently been increasing as the diversification of computer processing has proceeded. A smaller reproduction and recording head is thus needed to facilitate the provision of HDDs with a larger capacity. The applicant contemplates using an

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MR head to form a magnetic head for storing and reproducing information.

[0004]

A rotary actuator using a voice coil motor (VCM) is usually used to position the magnetic head in a specified position on the disk in the HDD due to the actuator's light weight, high speed, and low cost. The rotary actuator has a rotation axis outside the disk, and rotates the magnetic head located at its tip to position it in the specified position. Servo methods include a sector servo method used particularly in small HDDs to store surface patterns in each sector of each disk, and cylinder and sector numbers required for positional control. HDDs are required to determine the position of the head moving on the disk because they must carry out magnetic reproduction and storage in any position of a plurality of disks. The sector servo method reproduces servo information written on the disk to determine the track number and the exact position of the head relative to the center of the track.

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[0005]

General-purpose servo methods for HDDs use position error signals (referred to as PESs below) in servo information to detect an offset from the center of the track (referred to as the amount of offtrack below).

[0006]

Figure 11 (A) shows that servo patterns comprise servo patterns PA arranged continuously in one direction from the center of the track CL and servo patterns PB adjacent to the servo patterns PA which are arranged continuously in the other direction. The servo patterns PA, PB are stored on the track TR with signals of a constant amplitude. The HDD detects the offset of the center of the head from the center of the track based on the magnitude of the amplitude of the reproduction signal of each of these servo patterns PA, PB which is reproduced by the reproduction head RD.

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[0007]

For example, if the reproduction head RD passes the center of the track (see Figure 11 (A)), the amplitude Va of the reproduction signal Sa of the servo pattern PA matches the amplitude Vb of the reproduction signal Sb of the servo pattern PB. In this case, the amplitude ratio Va/(Va+Vb) = 1/2, and it is assumed that the reproduction head RD is located at the center of the track TR. The value of Va/(Va+Vb) is simply referred to as a PES value below.

[0008]

In addition, if the reproduction head RD is offset from the track in one direction as shown in Figure 11 (B), that is, the reproduction head RD is offset to the right (the direction of the + arrow in Figure 11) from the forward direction of the head RD, the amplitude Va of the reproduction signal Sa of the servo pattern PA decreases while the amplitude Vb of the reproduction signal Sb of the servo pattern PB increases. Thus, $Va/(Va+Vb) < 1/2$.

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The PES value becomes one half or less, indicating that the position of the reproduction head RD is offset to the right from the center of the track in the forward direction.

[0009]

Thus, if the sensitivity of the reproduction head RD is approximately uniform on a track of a width Tw, the relationship between the amount of offtrack and the PES value is ideally linear as shown in Figure 11 (C). The servo gain should thus be set to linearly correspond to the PES value to control the actuator so that the center of the reproduction head RD is located at the center of the track CL.

[0010]

Figure 13 shows an example of the functional blocks of a servo controller incorporated in a conventional HDD. This servo controller 12 has a driver 46 for supplying a current to a voice coil 54 that turns an actuator 50 with a recording and reproduction head 52 attached to the end of it. The output signal of the recording and

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reproduction head 52 is input to a PES value calculation means 56. The PES value calculation means 56 calculates digital data which is used as a PES value based on the analog output signal of the recording and reproduction head 52 produced by AD conversion. The servo controller 12 is a PID control system comprising an integral system 20, a differential system 30, and a comparison system 40.

[0011]

The comparison system 40 determines the deviation between the target value and the current displacement in proportion to the acceleration to determine the value of a current supplied to the voice coil 54, and comprises a synthesis means 62 and a coefficient application means 42, 44. The PES value used as a target for positioning the recording and reproduction head is input to one input of the synthesis means 62 from a target PES value output means 60, while digital data output from the PES value calculation means 56, that is, the value corresponding to the current displacement of the recording and reproduction head 52 is input to the other input the deviation between the

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two values is then output. Predetermined coefficients K_1, K_A are applied to this deviation (multiplication), and the resulting value is output to a driver 46.

[0012]

The differential system 30 attempts to quickly reduce and stabilize the deviation between the target value and the current displacement, and comprises a delay means 32, a synthesis means 70, and a coefficient application means 34. The synthesis means 70 outputs the difference between digital data from the PES value calculation means 56 and digital data delayed for a specified time, that is, the last digital data. A predetermined coefficient K_2 is applied to this output value (multiplication), and the resulting value is synthesized (addition) by a synthesis means 66 between the coefficient application means 42 and 44 in the comparison system 40.

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[0013]

The integral system 20 compensates for steady errors to quickly reduce and stabilize any deviations, and comprises a delay means 22, a synthesis means 64 and 68, and a coefficient application means 24. The synthesis means 64 synthesizes the deviation data from the synthesis means 62 and the data delayed for a specified time by the delay means 22, that is, the last digital data (addition). The coefficient application means 34 applies the predetermined coefficient K_2 to the output values output via the delay means 22 (multiplication), and the resulting value is synthesized (addition) by the synthesis means 66 between the coefficient application means 42 and 44 in the comparison system 40. Consequently, since the repetition of the above steps allows integration even with a slight deviation, the deviation can be automatically controlled to be zero. The synthesis means 68 may be located before the coefficient application means 44.

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[0014]

However, if the sensitivity of the reproduction head RD is not uniform, for example, the + sensitivity is larger than the - sensitivity as shown in Figure 12 (B) (see Figure 12 (A)), the relationship between the amount of offtrack and PES value is nonlinear. Thus, where the PES value varies sharply relative to the amount of offtrack (region Er where the gradient of the line representing the relationship between the PES value and displacement is large), the PES value changes substantially even when the position of the reproduction head RD changes slightly, resulting in a large servo gain in the control of the actuator compared to other positions. That is, as seen from the relationship between the amount of offtrack and servo gain in Figure 12 (C), in a region Eg corresponding to a region Er, the servo gain involves a sudden change and the control of the actuator is unstable. Consequently, if the sensitivity of the reproduction head RD is not uniform, the servo gain increases and decreases in several positions on a single track. This

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frequently occurs if an MR head is used as a recording and reproduction head.

[0015]

Therefore, the servo gain set to linearly correspond to the PES value does not allow the center of the head to be located at the center of the track CL.

[0016]

Since conventional recording and reproduction heads (for example, MIG and thin film heads) are used for both reproduction and recording, a single optimum gain constant for following the center of the track is set as the servo gain to enable the recording and reproduction head to follow the center of the track as a target.

[0017]

As is well known, however, in a head such as an MR head that requires separate reproduction and recording heads, the positions of the reproduction and recording

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heads are offset slightly from each other. As a result, when the reproduction head attempts to follow the center of the track, the recording head is offset slightly from the center of the track. To reproduce stored data after this data is recorded under these conditions, the reproduction head must be offset from the center of the track by the offset distance between the recording and reproduction heads. The MR head should thus follow not only the center of the track but also a specified position that is offset from the center.

[0018]

However, since, the servo gain of conventional recording and reproduction heads is linear with respect to the PES value, there is a large difference in the servo gain between recording and reproduction with an MR head. Thus, when the servo gain is provided with the calibration optimum for recording, it becomes too large for reproduction, resulting in unstable reproduction. In the conventional HDD devices, this in turn causes a high error rate during reproduction, or a

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servo gain that is too small for reproduction causes unstable recording.

In view of the above points, it is an object of this invention to provide a servo method for allowing a head comprising separate reproduction and recording heads to stably follow any position within a track when this head is used to record or reproduce data.

Summary of the Invention

According to the invention there is provided a servo method for a hard disk drive for using a head that at least reproduces information and has sensitivity which is not uniform to reproduce servo information for identifying a track position from an information recording disk comprising at least one track including at least one servo region in which said servo information is stored and using the reproduced servo information and predetermined gain information to provide feedback for the control of said head to be positioned in a predetermined reference position on said track,

wherein the correspondence between the distance information corresponding to the offset of said head from said reference position and said gain information is stored in advance,

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said reproduced servo information is used to derive the distance information corresponding to the offset of said head from said reference position,

said correspondence is referenced to derive the gain information corresponding to the distance information obtained, and

feedback control is carried out using the gain information derived and the reproduced servo information to position said head in the predetermined position on said track which may be said reference position.

The invention also provides a hard disk drive comprising:

a head that at least reproduces information and has sensitivity, part of which is not uniform;

an information recording disk comprising at least one track including at least one servo region in which said servo information for identifying a track position is stored;

a reproduction means for reproducing said servo information from said information recording disk;

a storage means for storing the correspondence between the distance information corresponding to the offset of said head from said reference position and said gain information;

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a distance information derivation means for using said reproduced servo information to derive the distance information corresponding to the offset of said head from said reference position; and

a feedback control means for referencing said correspondence, reading the gain information corresponding to the distance information derived, and using the read gain information and the reproduced servo information to position said head in the predetermined position on said track which may be said reference position.

Preferably, the head comprises a reproduction element for reproducing information and a storage element disposed at a specified interval from the reproduction element for storing the information.

Preferably, the head includes an MR head having a magnetoresistance (MR) effect.

In the invention in accordance with claim (1) that is a servo method for a hard disk drive head, the correspondence between the distance information corresponding to the offset of the head from the reference position and gain information is stored in advance to use a head that at least reproduces information and has sensitivity, part of which is not uniform, to reproduce servo information for identifying a track position from an information recording disk comprising at least one track including at least one

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servo region in which the servo information is stored and to use the reproduced servo information and the predetermined gain information to provide feedback for the control of the head to position it in a predetermined reference position on the track. The reproduced servo information is used to derive the distance information corresponding to the offset of the head from the reference position, and the correspondence is referenced to derive the gain information corresponding to the distance information obtained. Feedback control is carried out using the gain information derived and the reproduced servo information to position the head in the predetermined position on the track which may be a reference position. This prevents the offset of the head from the reference position from hampering the feedback control.

[0025]

According to claim (2), the above servo method for a hard disk drive head can be achieved using a hard disk drive comprising a head that at least reproduces information and has sensitivity, part of which is not

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uniform; an information recording disk comprising at least one track including at least one servo region in which the servo information for identifying a track position is stored; a reproduction means for reproducing the servo information from the information recording disk; a storage means for storing the correspondence between the distance information corresponding to the offset of the head from the reference position and the gain information; a distance information derivation means for using the reproduced servo information to derive the distance information corresponding to the offset of the head from the reference position; and a feedback control means for referencing the correspondence, reading the gain information corresponding to the distance information derived, and using the read gain information and the reproduced servo information to position the head in the predetermined position on the track which may be the reference position.

[0026]

As also set forth in claim (3), if the head comprises a reproduction element for reproducing information and a

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storage element disposed at a specified interval from the reproduction element for storing the information, the center of the head does not match the center of the track. That is, the center of the head does not match the center of the track when the servo information is reproduced while that stored information is written to an information recording disk, as in a sector servo method, and when both the servo information and the information stored on the information recording disk are reproduced, the center of the head on the track does not match the center of the track, consequently, each processing requires gain information as long as the gain information corresponding to the specified distance between the elements of the head is included in the correspondence, the feedback control of the head comprising the reproduction and the recording element is not affected by an error in the specified distance. The head may include an MR head having a magnetoresistance (MR) effect.

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A preferred embodiment of the invention is described below, by way of example only, with reference to the drawings.

Brief Description of the Drawings

Figure 1 is a functional block diagram of a servo controller to which the present invention is applicable;

Figure 2 is a block diagram illustrating a HDD to which this invention is applicable;

Figure 3 is an image view of a disk for HDDs;

Figure 4 is a chart illustrating the relationship between the amount of offtrack and the PES value for a conventional servo controller;

Figure 5 is a chart illustrating the relationship between the position of a magnetic head and the PES value;

Figure 6 is a chart illustrating the relationship between the target PES value and the gain;

Figure 7 describes a method for setting a coefficient for providing a constant servo gain in this embodiment;

Figure 8 is a flowchart describing the flow of processing by the servo controller of this embodiment;

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Figure 9 is a chart illustrating the relationship between the target PES value and the gain margin;

Figure 10 is a chart illustrating the relationship between the target PES value and the standard deviation;

Figure 11 describes a method for obtaining the amount of offtrack as a signal;

Figure 12 describes the relationship between the position of a head with a nonuniform characteristic and various other characteristics; and

Figure 13 is a functional block diagram of a conventional servo controller.

Reference numerals 10, 47 and 48 have the following significances:

10 servo controller

47 variable coefficient application means

48 table

Preferred Embodiment of the Invention

In this embodiment, the present invention is applied to an HDD 110 employing as a recording and reproduction head a magnetic head that is an MR head.

Figure 2 shows that the HDD 110 in accordance with this invention includes a drive 114 that rotates a shaft 112 at a high speed. That shaft 112 has a cylindrical support 116 attached thereto, and the support 116 has a plurality of disks 118A, 118B (two in Figure 2) installed on the outer circumferential surface thereof at a specified interval. The disks 118A, 118B have a disk shape and a specified thickness. The disks 118A, 118B are made of a hard material, and have a magnetic material coated on both

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sides for use as recording surfaces. An opening of substantially the same diameter as the outer diameter of the support 116 is

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direction of rotation of the disks 118A, 118B using a magnetic head as described below.

[0030]

The HDD 110 includes magnetic heads 58A to 58D of a specified gap width and length provided so as to correspond to each recording surface of the disks 118A, 118B. Each magnetic head 58A to 58D comprises a reproduction element that acts as an MR head to read information and a recording element for writing information. Each magnetic head 58A to 58D is attached to the end of the corresponding access arm 50A to 50D, and held at a small distance (for example, about 0.1 to 0.2 micron) from the corresponding recording surface of the disks 118A and 118B. The trailing ends of the access arms 50A to 50D are attached to a support section 124. The support section 124 is fitted to a drive 128 via a shaft 126, and the access arms 50A to 50D are turned when the drive 128 rotates through a specified angle. The turning of the access arms 50A to 50H moves each magnetic head 58A to 58D radially (see Figure 3) on each recording surface of the disks 118A,

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118B until it is positioned in a specified section on the recording surface.

[0031]

The drive 128 is connected to a hard disk controller 130 (referred to as an HDC below) including a microcomputer. The HDC 130 is in turn connected to each of the magnetic heads 58A to 58D for recording and reproducing information. The HDC 130 also includes a controller 61 (see Figure 1) and a servo controller 10. The drive 128 comprises a driver 46 including a digital-analog converter (D/A) and an amplification circuit (AMP), and a voice coil 54 such as a voice coil motor (VCM). Consequently, when the voice coil 54 rotates through a specified angle in response to a signal output from the HDC 130, the access arms 50A to 50D rotate through a predetermined angle.

[0032]

Next, the servo controller 10 incorporated in the HDD 110 of this embodiment is described in detail. For the convenience of the following description, the magnet

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head 58A is described by way of example. In addition, since the servo controller 10 of this embodiment has a configuration approximately similar to that of the servo controller 12 described in the section on the prior art, the corresponding components carry the same reference numerals as in that section and a detailed description of them is omitted.

[0033]

Figure 1 is a functional block diagram illustrating the servo controller 10 of this embodiment. Digital data output from a PES value calculation means 56 is also input to a controller 61. The PES value calculation means 56 and controller 61 may be integrated.

[0034]

A comparison system 40 comprises a synthesis means 62, coefficient application means 42, a variable coefficient application means 47, and a table 48. The PES value used as a target for positioning the magnetic head 58A that is an MR head is input from the controller 61 to one input of the synthesis means 62,

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while the digital data output from the PES value calculation means 56, that is, the value corresponding to the current displacement of the magnetic head 58A, is input to the other; the deviation between the two values is then output. A predetermined K_1 is applied to this deviation (multiplication), and the resulting value is input to the variable coefficient application means 47. The variable coefficient application means 47 varies and sets a coefficient K_a in accordance with a value input from the table 48. The correspondence between the PES value used as a target and the coefficient K_a used as a gain constant for the PES value is stored in the table 48 in advance so that the coefficient K_a is small when the PES value varies sharply and that the coefficient K_a is large when the PES value is small. The variable coefficient application means 47 applies the coefficient K_a set in accordance with the value input from the table 48 to the value input from a synthesis means 66 (multiplication); the resulting value is then output to a driver 46.

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[0035]

The description of the differential system 30 and the integral system 20 is omitted because they are similar to those in the section on the prior art. A synthesis means 68 may be located before the coefficient application means 44.

[0036]

Next, the MR head used in this embodiment is described in comparison with the conventional head. In the following description, it is assumed that the head is positioned in the center of the track when the width of the track is 256 and the PES value is 128.

[0037]

Figure 4 shows that the conventional head does not have to seek a position other than the center of the track and that a servo system is used to provide feedback for the control of the center of the head to follow the center of each track because the relationship between the amount of offtrack of the head from the center of

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the track and the PES value = A/(A+B) is linear and a common head gap is used for both recording and reproduction.

[0038]

The MR head requires separate head gaps for recording and reproduction. Thus, if data is recorded while the center of the track is being followed using the reproduction gap, then the data is written in a position offset by the distance equal to the difference between the reproduction and the recording gap. To read the data, the reproduction gap must be offset from the center of the track by the same distance.

[0039]

Figure 5 shows that a characteristic 80 indicating the relationship between the amount of offtrack of the MR head and the PES value is not linear as in Figure 4; it is nonlinear and like a quadratic curve. The difference delta between the PES value of the characteristic 80 and the PES value of the linear characteristic at each of these sample points is shown

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as a characteristic 82. In the characteristic 82, a large value means that the PES value varies sharply due to a slight change in head position. In the characteristic 82 in Figure 5, the difference delta is largest when the PES value is about 170 to 180.

[0040]

The HDD employing an MR head thus is required to seek positions other than the center of the track and has a non-linear relationship between the amount of offtrack and the PES value.

[0041]

In Figure 6, a characteristic 84 indicates the relationship between the gain and PES value at a phase of 0°. This absolute value of the gain indicates a gain margin. In addition, a characteristic 86 indicates the relationship between the standard deviation σ and the head position when 500 PES values are sampled continuously. The standard deviation σ indicates the degree of instability in the track-following operation.

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[0042]

As can be seen from Figure 6, the gain margin is related closely to the standard deviation σ. That is, the standard deviation σ is large when the gain margin is small and the PES value is within a range of 158 to 168, whereas it is small where the gain margin is large. The inventors experimented with other HDDs with a few changes in gain margin over all of the tracks to confirm that the standard deviation σ of the head is approximately the same and stable over all of the tracks.

[0043]

Thus, when the difference delta is larger, the servo system for positioning the MR head is more sensitive than for other positions with smaller difference delta. Consequently, the gain for the PES value for controlling an actuator is large and the gain margin is small where the difference delta is large. The track-following operation becomes more instable as the gain margin decreases.

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[0044]

As can be seen from the above, the nonlinearity of the head is related closely to the instability of the servo system.

[0045]

Next, the operation of the periphery of the servo controller 10 incorporated in the HDD 110 of this embodiment is described in detail.

[0046]

If the characteristic of the magnetic head is nonlinearity between the amount of offtrack and the PES value, as shown in Figure 7 (A), the servo gain is large when the change rate of the PES value is largest and it is small when the change rate is smallest, as described above in Figure 7 (B), because the conventional gain constant involves a constant coefficient. With this embodiment, the table can be referenced to vary the coefficient K_a to correspond to

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the target PES value. Thus, when the variation of the PES value is large, the coefficient K_a is given a small value. This allows the servo gain to have a constant value. When the variation of the PES value is small, the coefficient K_a is given a large value. This allows the servo gain to have a constant value. As a result, as shown in Figure 7 (D), the servo gain is approximately constant for any amount of offtrack, resulting in an optimum following performance for any amount of offtrack.

[0047]

In this manner, the optimum gain constant, that is, the optimum coefficient K_a for a target PES value is measured and stored in advance in microcode as a table. If a target PES value is input when the magnetic head actually starts seeking, the optimum gain constant is determined from the table in accordance with the value and applied to the servo system as the coefficient K_a.

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[0048]

The above operation is described using the processing routine shown in Figure 8. When the magnetic head starts seeking, a target PES value is obtained in step 200 of the servo coefficient setting routine in Figure 8. In the subsequent step 202, the table 48 is used to create a table based on a one-to-one correspondence between the target PES value and the coefficient. In subsequent step 204, the table which has been created is referenced to set a variable coefficient K_a for the variable coefficient application means 47.

[0049]

An example of an operation in this case is shown below. First, the gain constant is set to the default. Each target PES value is then set, a current of 475 Hz is applied to the voice coil, and the response is calculated to determine the optimum the gain constant. These values are stored in the table as gain constants for the respective target PES values. For the magnetic head shown in Figure 6, the gain constant is small when

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the PES value is within a range of 158 to 168 and the gain is very large, whereas it is large where the gain is small.

[0050]

Thus, since, in this embodiment, the use of a variable coefficient allows the gain constant for feedback control to vary in accordance with the target PES value, even when the magnetic head has a nonlinear PES value, the servo system does not become instable despite changes in gain within a single track, and the optimum track-following operation can be performed at each position.

[0051]

A servo controller 10 to which the servo system of the above embodiment is applied was experimentally produced and compared with a conventional servo controller 12 with the results in Figures 9 and 10. Figure 9 demonstrates the relationship between the gain and target PES value at a phase of 0°. Figure 10 demonstrates the relationship between the target PES

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value and the standard deviation σ of 1,000 responsive PES values sampled after a track-following operation for each target PES value. The solid line in Figures 9 and 10 indicates the results of the experiment with the servo controller 12; the alternate dot-dash line indicates the results of the experiment with the servo controller 10 to which the servo system of the embodiment is applied.

[0052]

This experiment was only conducted for the cylinder = 2,700 of head = 3 of Unit S/N:V18506, and two gain constants were used. That is, for the target PES value =< 129, the gain constant calibrated at the value of 128 (normal gain value) was used; for the target PES value >129, 75% of the gain constant at the value of 128 (sensitive area gain value) was used. However, the sensitive area gain value is substantially equal to the gain constant calibrated using this HDD, cylinder, and reproduction position (about 150).

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[0053]

As can be seen from the figures, for the conventional servo controller, the gain margin is smaller when the target PES value is within a range of about 148 to 188. On the contrary, the standard deviation σ is larger within this range. In the servo controller of this embodiment, although the gain constant for the target PES value >129 is 75% of that of the conventional servo system, Figure 9 clearly indicates that the gain margin of this embodiment is higher than that of the conventional servo controller when the target PES value is 138 or more. The standard deviation σ that is large when the target PES value is within a range of about 158 to 188 decreases with the change in gain margin. There is no effect from the change in gain margin when the standard deviation σ is small.

[0054]

For example, if the target PES value is set to 168 for seeking during reproduction, the offset of the reproduction/recording gap causes the conventional servo controller to be very instable during

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reproduction, resulting in a high soft error rate (recoverable error rate). However, a decrease in the gain allows the servo controller of this embodiment to provide a stable track-following operation during reproduction, resulting in a low soft error rate.

[0055]

As described above, since the correspondence between the distance information corresponding to the offset of the head from the reference position and the gain information is stored in advance, the gain information corresponding to the offset of the head from the reference position and the servo information can be used to provide feedback for the control of the head to be positioned at a predetermined position on the track which may be the reference position. This prevents the feedback control from being affected by the offset of the head from the reference position, and allows the head to stably follow the track.

Claims:

1. A servo method for a hard disk drive for using a head that at least reproduces information and has sensitivities which are not uniform within a single track width to reproduce servo information for identifying a track position from an information recording disk comprising at least one track including at least one servo region in which said servo information is stored and using the reproduced servo information and predetermined gain information to provide feedback for the control of said head to be positioned in a predetermined reference position on said track,

wherein the correspondence between the distance information corresponding to the offset within a single track width of said head from said reference position and said gain information is stored in advance,

said reproduced servo information is used to derive the distance information corresponding to the offset of said head from said reference position,

said correspondence is referenced to derive the gain information corresponding to the distance information obtained, and

feedback control within a single track width is carried out using the gain information derived and the reproduced servo information to position said head in the predetermined position on said track which may be said reference position.

2. A hard disk drive comprising:

a head that at least reproduces information and has sensitivities, part of which are not uniform within a single track width;

an information recording disk comprising at least one track including at least one servo region in which said servo information for identifying a track position is stored;

a reproduction device for reproducing said servo information from said information recording disk;

a storage device for storing the correspondence between the distance information corresponding to the offset of said head from said reference position and said gain information;

a distance information derivation device for using said reproduced servo information to derive the distance information corresponding to the offset within a single track width of said head from said reference position; and

a feedback control device for referencing said correspondence, reading the gain information corresponding to the distance information derived, and using the read gain information and the reproduced servo information to position said head in the predetermined position on said track which may be said reference position.

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3. A hard disk drive in accordance with claim 2 wherein said head comprises a reproduction element for reproducing information and a storage element disposed at a specified interval from the reproduction element for storing the information.

4. A hard disk drive in accordance with claim 2 wherein said head includes an MR head having a magnetoresistive effect.

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a feedback control device for referencing the correspondence, for reading the gain information corresponding to the derived distance information, and for using the derived gain information and the servo information to position the head in a predetermined position on a track.

7. A hard disk drive as claimed in claim 6 wherein the head includes a reproduction element for reproducing information and an information storage element disposed at a specified interval from the reproduction element.

8. A hard disk drive as claimed in claim 6 wherein the head includes an MR head having a magnetoresistive effect.

9. A hard disk drive comprising:

a head including a reproduction element for reproducing information and a storage element disposed at a specified distance from the reproduction element for storing the information;

an information recording disk including a track having a servo region with servo information for identifying a track position;

a device for obtaining gain information corresponding to the specified distance between the reproduction element for reproducing information of the head and a storage element of the head; and

a feedback device for controlling the location of the head within a single track width, the feedback device being responsive to the gain information and thereby account for the specified distance between the reproduction element and the storage element in the head.

10. A hard disk drive as claimed in claim 9 wherein the head responds nonlinearly between an amount of an off-track from the center of the track relative to the head and including having a position error signal in the servo information for detecting the offset; and

a device for varying the gain in relation to a target position error signal value thereby to maintain an effective gain for the feedback means substantially constant and independent of the amount of off-track.

11. A hard disk drive as claimed in claim 10 including a device for obtaining a predetermined gain constant for the target position error signal and for storing the value in a table.

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REPLACEMENT SHEET
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12. A hard disk drive as claimed in claim 11 wherein the head is a magnetic head, and including a device for inputting a target position error signal value into the magnetic head, means for determining a selected gain constant from the table in accordance with the value, and a device for applying the value to the feedback means.

13. A method of controlling the location of a head for a hard disk drive wherein the head includes a reproduction element for reproducing information and a storage element disposed at a specified distance from the reproduction element for storing the information; and wherein there is an information recording disk including a track having a servo region with servo information for identifying a track position; the method comprising:

obtaining gain information corresponding to the specified distance between the reproduction element for reproducing information of the head and a storage element of the head; and

controlling the location of the head within a single track width in response to the gain information and thereby to account for the specified distance between the reproduction element and the storage element in the head.

14. A method as claimed in claim 13 wherein the head responds nonlinearly between an amount of off-track from the center of the track relative to the head, and including a position error signal in the servo information for detecting the offset; and including varying the gain in relation to a target position error signal value thereby to maintain an effective gain for the feedback means substantially constant and independent of the amount of off-track.

15. A method as claimed in claim 14 including obtaining a predetermined gain constant for the target position error signal and storing the value in a table.

16. A method as claimed in claim 15 wherein the head is a magnetic head, and including inputting a target position error signal value into the magnetic head, determining a selected gain constant from the table in accordance with the value, and applying the value for head control.

17. A method as claimed in claim 16 and including inputting the target position error signal value into a magnetic head, determining a selected gain constant from the table in accordance with the value, and applying the value for head position control.

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