

SERVO WRITING METHOD AND SERVO WRITER

Technical Field of the Invention

The present invention relates to a servo writing method and a servo writer, and more specifically to a servo writing method and a servo writer for writing, on a magnetic disc, a servo pattern used to detect the position of a magnetic head, an ID pattern for identifying the magnetic disc, a program, etc.

Prior Art

Enhancement in positioning precision of a magnetic head contributes to increase storage capacity in a magnetic disc device. Various tracking servo systems have been known to enhance the positioning precision of a magnetic head, that is, the tracking precision. A device for recording a servo signal for positioning a magnetic head, that is, a servo pattern on a magnetic disc is called as a servo writer.

Fig. 1 shows the construction of a conventional servo writer. The servo writer is equipped with a disc stack unit 13 in which magnetic discs 11 of n for recording servo signals thereon and a clock pattern disc 12 are fixed, and a spindle motor 14 for rotating the disc stack unit 13 at several thousands rpm. The servo writer is further equipped with a clock head 15 for writing a clock pattern on the clock pattern disc

12, a clock head positioner 16 for positioning the clock head 15, magnetic recording heads 17 for writing servo patterns on the magnetic discs, and a rotary positioner 18 for positioning the magnetic recording heads stacked.

Furthermore, the servo writer is equipped with a clock pattern generator 21 for generating a clock pattern, a servo pattern generator 22 for generating a servo pattern, a position detector 23 connected to a rotary encoder 19 for detecting the position of the rotary positioner 18, a servo compensator 24 for calculating a servo compensation value on the basis of an error between the detected position and a target position, and a power amplifier 25 for outputting a driving current for the rotary positioner 18 on the basis of the servo compensation value.

The operation of the servo writer will be described. As shown in Fig. 2(a), the clock head 15 writes the clock pattern generated in the clock pattern generator 21 at any radial position of the clock pattern disc 12. For example, the clock pattern 31 is written on the outermost periphery of the clock pattern disc 12 as shown in Fig. 2(b).

Next, the position of the rotary positioner 18 is detected by the rotary encoder 19 and the position detector 23, and the error from the target position is fed back through the servo

compensator 24 and the power amplifier 25, and each magnetic recording head 17 is made to follow the target position as shown in Fig. 2 (a). Each magnetic recording head 17 writes the servo pattern generated in the servo pattern generator 22 on each magnetic disc 11 in synchronism with clocks read out from the clock pattern disc 12 under the followed state.

With respect to the conventional servo writer, the time required for one disc stack unit to write the servo pattern on the whole surface of each magnetic disc is equal to the disc rotation time $\times$ the number of tracks to be written. As the track density is enhanced in connection with increase in storage capacity, the writing time is longer and the throughput is lowered. The time can be shortened by increasing the rotational speed of the magnetic disc. However, the mechanical vibration is intensified as tradeoff, and it is difficult to write the servo pattern with high precision. If the stack number of magnetic discs is increased, the throughput per one disc is increased, however, the load imposed on a spindle motor is increased, so that the rotation precision is lowered. Furthermore, the number of magnetic recording heads stacked is increased, so that it is difficult to keep the installation precision within a predetermined range.

Therefore, it has been carried out to divide one sector

in the radial direction and write the servo pattern with plural magnetic recording heads, thereby shortening the writing time. Furthermore, there is known a method with which plural magnetic recording heads are equipped and a reference position signal indicating a reference position is recorded on a magnetic disc to record a servo pattern (see Patent JP-A-11-260008). Furthermore, it is known that setup magnetic recording heads are corrected by loading a disc for correction (see Patent JP-A-2002-208242 for example).

Problem to be solved by the Invention

However, in the servo writer equipped with the plural magnetic recording heads as described above, dispersion in magnetic density occurs on the magnetic face of a magnetic disc even when an exciting current to be applied to the exciting coils of the magnetic recording heads is constant. This is caused by a factor based on the magnetic recording head such as dimensional dispersion of constituent elements of the magnetic recording head such as the gap interval of yokes, for example, dispersion of materials constituting the yokes, and also by a factor based on the float amount of the magnetic recording head from the magnetic disc.

Fig. 3 shows the relationship between the magnetic density and coercive force of the magnetic material. Servo

patterns written with different magnetic flux densities (H_1 , H_2 , H_3) are different in coercive force (M_1 , M_2 , M_3). When a servo pattern is read out by a magnetic reproducing head under such a state, the amplitude value is different among the magnetic recording heads as shown in Fig. 4(B) or Fig. 4(C) with respect to a magnetic reproduction signal shown in Fig. 4(a). Therefore, there is a problem that if the magnetic reproduction signal has no sufficient S/N, it would be difficult to set a threshold value for binarization.

The present invention has been implemented in view of the problem as described above, and has an object to provide a servo writing method and a servo writer that can achieve a magnetic reproduction signal having uniform amplitude even when plural magnetic recording heads are equipped.

Means of solving the Problem

In order to attain the above object, according to the invention of claim 1, a servo writing method in which CPU of a servo writer having plural magnetic recording heads writes a servo pattern on a magnetic disc, is characterized by comprising: a recording step of controlling an exciting current controller so that all exciting currents to be applied to the plural magnetic recording heads are constant, and recording a magnetic pattern on the magnetic disc; a reading step of

reading out a magnetic reproduction signal based on the magnetic pattern recorded on the magnetic disc by one magnetic reproducing head; a detecting step of achieving peak values from a peak detector for detecting and holding peaks of the amplitude value of the magnetic reproduction signal; and a normalizing step of calculating an average value of the magnetic reproduction signals corresponding to the magnetic recording heads from the peak values thus achieved and dividing the amplitude value of each magnetic reproduction signal by the average value to normalize the amplitude value, wherein the CPU stores as a correction value the inverse number of the amplitude value normalized in the normalizing step, and supplies the correction value to the exciting current controller when the servo pattern is written on the magnetic disc.

According to this method, dispersion of the writing characteristic of the magnetic recording head is compensated before the servo pattern is written. Therefore, even when plural magnetic recording heads are equipped, the magnetic reproduction signal having uniform amplitude can be achieved.

The invention of claim 2 is characterized in that the detecting step of claim 1 detects the peaks of the amplitude values of the plural magnetic reproduction signals, and

calculates and holds the average value thereof.

The invention of claim 3 is characterized in that the detecting step of claim 2 or 3 detects positive and negative peaks of the magnetic reproduction signals, and the normalizing step adds the positive and negative peaks for normalization.

According to the invention of claim 4, a servo writer for writing a servo pattern on a magnetic disc by using plural magnetic recording heads, is characterized by comprising: exciting current control means for applying an exciting current to each of the magnetic recording heads to record a magnetic pattern on the magnetic disc; a magnetic reproducing head for reading out a magnetic reproduction signal based on the magnetic pattern recorded on the magnetic disc; peak detecting means for detecting peaks of the amplitude value of the magnetic reproduction signal read out by the magnetic reproducing head and holding the peak values thereof; and CPU for controlling the exciting current control means to record the magnetic pattern on the magnetic disc so that all the exciting currents to be applied to the plural magnetic recording heads are kept constant, calculating the average value of the magnetic reproduction signals corresponding to the respective magnetic recording heads from the peak values obtained by the peak detecting means, dividing the amplitude value of each of

the magnetic reproduction signals by the average value to normalize the amplitude value, storing the inverse number of the amplitude value thus normalized as a correction value, and giving the correction value to the exciting current control means when the servo pattern is written on the magnetic disc.

The invention of claim 5 is characterized in that the peak detecting means of claim 4 detects the peaks of the amplitude values of the plural magnetic reproduction signals, and calculates and holds the average value thereof.

The invention of claim 6 is characterized in that the peak detecting means of claim 4 or 5 detects the positive and negative peaks of the magnetic reproduction signals to hold the positive and negative peak values, and the CPU adds the positive and negative peak values for normalization.

The invention of claim 7 is a program characterized in that CPU of a servo writer for writing a servo pattern on a magnetic disc by using plural magnetic recording heads is made to execute: a recording step of controlling an exciting current controller so that all exciting currents to be applied to the plural magnetic recording heads are constant, and recording a magnetic pattern on the magnetic disc; a reading step of reading out a magnetic reproduction signal based on the

magnetic pattern recorded on the magnetic disc by one magnetic reproducing head; a detecting step of achieving peak values from a peak detector for detecting and holding peaks of the amplitude value of the magnetic reproduction signal; and a normalizing step of calculating an average value of the magnetic reproduction signals corresponding to the magnetic recording heads from the obtained peak values and dividing the amplitude value of each magnetic reproduction signal by the average value to normalize the amplitude value concerned, wherein the CPU is made to store as a correction value the inverse number of the amplitude value normalized in the normalizing step and supply the correction value to the exciting current controller when the servo pattern is written on the magnetic disc.

The invention of claim 8 is characterized in that the detecting step of claim 7 detects the peaks of the amplitude values of the plural magnetic reproduction signals and calculating and holding the average value thereof.

The invention of claim 9 is characterized in that the detecting step of claim 7 or 8 detects positive and negative peaks of the magnetic reproduction signals, and the normalizing step adds the positive and negative peaks for normalization.

Brief Description of the Drawings

Fig. 1 is a diagram showing the construction of a conventional servo writer.

Fig. 2 is a plan view showing a clock head and a magnetic recording head in the conventional servo writer.

Fig. 3 is a diagram showing the relationship between magnetic density and coercive force of magnetic material.

Fig. 4 is a diagram showing the amplitude value of a magnetic reproduction signal.

Fig. 5 is a diagram showing the construction showing a servo writer according to an embodiment of the present invention.

Fig. 6 is a plan view showing a magnetic reproducing head and a magnetic recording head in the servo writer.

Fig. 7 is a flowchart showing a servo writing method according to the embodiment of the present invention.

Fig. 8 is a diagram showing the circuit construction of an exciting current controller according to the embodiment of the present invention.

Fig. 9 is a diagram showing the circuit construction of a peak detector according to the first embodiment of the present invention.

Fig. 10 is a diagram showing the circuit construction of a peak detector according to a second embodiment of the present invention.

Fig. 11 is a diagram showing the circuit construction of a peak detector according to a third embodiment of the present invention.

Fig. 12 is a diagram showing the circuit construction of a peak detector according to a fourth embodiment of the present invention.

Embodiment of the Invention

An embodiment of the invention will be described hereunder in more detail with reference to the drawings.

Fig. 5 shows a servo writer according to an embodiment of the present invention. The servo writer is equipped with a disc stack unit 53 in which magnetic discs 51 of n for recording servo signals thereon and a clock pattern disc 52 are fixed, and a spindle motor 54 for rotating the disc stack unit 53 at several thousands rpm.

The servo writer is further equipped with a clock head 55 for reading out a clock pattern from the clock pattern disc 52, magnetic recording heads 57a to 57c for writing a servo pattern on a magnetic disc 51, and three sets of rotary positioners 58a to 58c for positioning the magnetic recording heads 57a to 57c stacked. One sector of the magnetic disc 51 is divided in the radial direction, and a servo pattern is

written by the plural magnetic recording heads to thereby shorten the writing time.

Furthermore, the servo writer is connected to a rotary encoder 59 for detecting the position of the rotary positioners 58, and the servo writer is further equipped with a head position/clock detector 61 connected to the clock head 55 for reading out the clock pattern, a servo pattern generator 62 for generating a servo pattern, a servo compensator 64 for calculating a servo compensation value from the error between a detected position and a target position, and a power amplifier 65 for outputting a driving current for the rotary positioners 58 on the basis of the servo compensation value.

According to this embodiment, the servo writer is further equipped with magnetic reproducing heads 71 for reading out the servo patterns written on the magnetic discs 51, a rotary positioner 72 for positioning the magnetic reproducing heads 71 stacked, a peak detector 73 for detecting the peaks of the amplitude value of a magnetic reproduction signal, and CPU 74 and exciting current controllers 75 that calculate the exciting currents to be applied to the magnetic recording heads on the basis of the peak values and apply the exciting currents to them. The exciting current controllers 75 whose number corresponds to the number of the magnetic

recording heads 57 stacked in the three sets of rotary positioners 58a to 58c are needed, however, they are omitted from the illustration.

According to the construction described above, the position of the rotary positioner 58 is detected by the head position/clock detector 61, and the error from the target position is fed back through the servo compensator 64 and the power amplifier 65 to make each of the magnetic recording heads 57a to 57c follow the target position. Under the followed state, each of the magnetic recording heads 57a to 57c writes the servo pattern generated in the servo pattern generator 62 on the magnetic disc 51 in synchronism with the clocks read out from the clock pattern disc 52.

Fig. 7 shows a servo writing method according to an embodiment of the present invention. In this embodiment, dispersion of the writing characteristic in the magnetic recording head is compensated before the servo pattern is written thereon. First, CPU 74 controls the exciting current controller 75 so that all the amplitude values of the exciting currents to be applied to the magnetic recording heads 57 are fixed to a predetermined value (S62). Each magnetic recording head 57 indicates a track to be written and records a magnetic pattern on the magnetic disc 51 in synchronism with the clocks

read out from the clock pattern disc 52 (S64).

Since the tracks on which the writing has been carried out by using the magnetic recording head 57 is known, the magnetic reproducing head 71 is positioned. Under this state, the position control of the magnetic reproducing head 71 is switched on the basis of the magnetic pattern, and a magnetic reproduction signal is read out from each magnetic disc 51 (S66). At this time, the peak detector 73 detects and holds one peak or both the peaks of the amplitude value of each magnetic reproduction signal (S68).

CPU 74 achieves the peak values held in the peak detector 73, calculates the average value of the magnetic reproduction signals corresponding to the respective magnetic recording heads 57 and divides the amplitude value of each magnetic reproduction signal by the average value to normalize the amplitude value. CPU 74 stores the inverse number of the amplitude value thus normalized as a correction value (S70). When the servo pattern is recorded on the magnetic disc 51, CPU 74 supplies the correction value to the exciting current controller 75, and applies the exciting current of the amplitude value thus compensated to each magnetic recording head 57 (S72).

The magnetic pattern written to compensate the dispersion of the writing characteristic is deleted by controlling the exciting current controller 75 so that all the amplitude values of the exciting currents applied to the magnetic recording heads 57 are equal to the predetermined value, and making the exciting currents flow in the opposite direction.

Fig. 8 shows the exciting current controller according to the embodiment of the present invention. The exciting current controller 75 includes a pulse amplitude conversion circuit 81 for determining the amplitude value of the exciting current, an alternating couple/bias circuit 82, and a constant current circuit 83 for outputting the exciting current corresponding to the amplitude value thus determined. The pulse amplitude conversion circuit 81 inputs the servo pattern generated in the servo pattern generator 62 as a recording system Write signal. Furthermore, a digital signal from CPU 74 is converted to an analog signal by a D/A converter 84, and then applied to the recording system Write signal. As described above, the exciting current of the amplitude value for which the dispersion of the writing characteristic is compensated is output to the magnetic recording head 57 via the alternating couple/bias circuit 82 and the constant current circuit 83.

Fig. 9 shows the peak detector according to the first embodiment of the present invention. The peak detector 73 is equipped with a high pass filter (HPF) circuit 85, a sampling/hold (S/H) circuit 86 for sampling a magnetic reproduction signal on the basis of an S/H signal, and a peak value detecting circuit 87 for holding the peak value of the amplitude value thus sampled, converting it to a digital signal by an A/D converter 88 and then outputting the digital signal to CPU 74. The peak detector may be designed so that the high pass filter (HPF) circuit 85 is omitted as in the case of a second embodiment shown in Fig. 10.

Fig. 11 shows a peak detector according to a third embodiment of the present invention. Normally, the magnetic reproduction signal is symmetric between positive and negative sides, so that it is sufficient to detect only the peak value at the positive waveform side by the peak detector shown in Figs. 9 and 10. However, according to the third embodiment, the peak values of both the positive and negative waveforms are allowed to be detected in order to enhance the detection precision. Furthermore, in a fourth embodiment shown in Fig. 12, the peak values of both the positive and negative waveforms are separately detected.

According to this embodiment, before the servo patten is

written, the dispersion of the writing characteristic in the magnetic recording head is compensated, so that magnetic reproduction signals having uniform amplitude can be achieved even when plural magnetic recording heads are equipped.

Advantageous Effect of the Invention

As described above, according to the present invention, CPU of the servo writer records a magnetic pattern so that all the exciting currents applied to plural magnetic recording heads are constant, the correction value corresponding to each magnetic recording head is calculated and stored on the basis of the peak value of the magnetic reproduction signal read out by one magnetic reproducing head, and the correction value is supplied to the exciting current controller when the servo pattern is written on the magnetic disc, so that the magnetic reproduction signal having uniform amplitude can be achieved even when plural magnetic recording heads are equipped.

CLAIMS

1. A servo writing method in which CPU of a servo writer having plural magnetic recording heads writes a servo pattern on a magnetic disc, characterized by comprising:

a recording step of controlling an exciting current controller so that all exciting currents to be applied to said plural magnetic recording heads are constant and recording a magnetic pattern on the magnetic disc;

a reading step of reading out a magnetic reproduction signal based on the magnetic pattern recorded on the magnetic disc by one magnetic reproducing head;

a detecting step of achieving peak values from a peak detector for detecting and holding peaks of an amplitude value of the magnetic reproduction signal; and

a normalizing step of calculating an average value of the magnetic reproduction signals corresponding to said magnetic recording heads from the obtained peak values and dividing the amplitude value of each magnetic reproduction signal by the average value to normalize the amplitude value concerned, wherein the CPU stores as a correction value the inverse number of the amplitude value normalized in said normalizing step, and supplies the correction value to the exciting current controller when the servo pattern is written on the magnetic disc.

2. The servo writing method according to claim 1, wherein said detecting step detects the peaks of the amplitude values of the plural magnetic reproduction signals and calculating and holding the average value thereof.

3. The servo writing method according to claim 2 or 3, wherein said detecting step detects positive peaks and negative peaks of the magnetic reproduction signals, and said normalizing step adds the positive peaks and the negative peaks for normalization.

4. A servo writer for writing a servo pattern on a magnetic disc by using plural magnetic recording heads, characterized by comprising:

exciting current control means for applying exciting current to each of said magnetic recording heads to record a magnetic pattern on the magnetic disc;

a magnetic reproducing head for reading out a magnetic reproduction signal based on the magnetic pattern recorded on the magnetic disc;

peak detecting means for detecting the peak of an amplitude value of the magnetic reproduction signal read out by said magnetic reproducing head and holding the peak value thereof; and

CPU for controlling said exciting current control means to keep constant all the exciting currents to be applied to said plural magnetic recording heads and record the

magnetic pattern on the magnetic disc, calculating the average value of the magnetic reproduction signals corresponding to the respective magnetic recording heads from the peak values obtained by the peak detecting means, dividing the amplitude value of each of the magnetic reproduction signals by the average value to normalize the amplitude value, storing the inverse number of the amplitude value thus normalized as a correction value, and giving the correction value to said exciting current control means when the servo pattern is written on the magnetic disc.

5. The servo writer according to claim 4, wherein said peak detecting means detects the peaks of the amplitude values of the plural magnetic reproduction signals, and calculates and holds the average value thereof.

6. The servo writer according to claim 4 or 5, wherein said peak detecting means detects the positive peaks and negative peaks of the magnetic reproduction signals to hold the positive peak values and the negative peak values, and said CPU adds the positive peak values and the negative peak values for normalization.

7. A program, characterized in that CPU of a servo writer for writing a servo pattern on a magnetic disc by using plural magnetic recording heads is made to execute:

a recording step of controlling an exciting current controller so that all exciting currents to be applied to said

plural magnetic recording heads are constant and recording a magnetic pattern on the magnetic disc;

a reading step of reading out a magnetic reproduction signal based on the magnetic pattern recorded on the magnetic disc by one magnetic reproducing head;

a detecting step of achieving peak values from a peak detector for detecting and holding peaks of an amplitude value of the magnetic reproduction signal; and

a normalizing step of calculating an average value of the magnetic reproduction signals corresponding to said magnetic recording heads from the obtained peak values and dividing the amplitude value of each magnetic reproduction signal by the average value to normalize the amplitude value concerned, wherein the CPU is made to store as a correction value the inverse number of the amplitude value normalized in said normalizing step and supply the correction value to the exciting current controller when the servo pattern is written on the magnetic disc.

8. The servo writing method according to claim 7, wherein said detecting step detects the peaks of the amplitude values of the plural magnetic reproduction signals and calculating and holding the average value thereof.

9. The servo writing method according to claim 7 or 8, wherein said detecting step detects positive peaks and negative peaks of the magnetic reproduction signals, and said

normalizing step adds the positive peaks and the negative peaks for normalization.