159159

G00002

APPARATUS FOR RECORDING AND/OR REPRODUCING DATA

FIELD OF INVENTION

The present invention relates to an apparatus for recording and/or reproducing data on a disk and reproducing digital data from a disk, and refers particularly, though not exclusively, to an apparatus for maintaining the quality of the servo error signal to aid servo error detection.

DESCRIPTION OF RELATED ART

The quality of a signal remarkably deteriorates due to a servo error such as the tilt and detrack of a disk as recording density becomes higher not only in a disk only for reproduction such as a DVD-ROM but also in a recordable disk such as a DVD-RAM. In particular, in the recordable disk, recording quality deteriorates due to the influence of the servo error when the servo error exists during recording and the deterioration of the quality of the signal becomes severe due to the servo error during the reproduction of a concerned part.

In a DVD-RAM disk, information is recorded on a track. The track is comprised of a land track and a groove track. The land track and the groove track alternate when the disk rotates once. The land track and the groove track are alternated in the DVD-RAM disk in order to provide a tracking guide in an initial stage and to reduce crosstalk between adjacent tracks in a high density narrow track.

The track is comprised of sectors having a uniform length. A pre-embossed header area is provided during the manufacturing of the disk as a means of physically dividing the sectors. The physical addresses of the sectors are recorded in the pre-embossed header area.

Each sector is comprised of a header area in which physical identification data (PID) is recorded and a data area.

FIG. 1A shows the physical shape of the land track in a DVD-RAM disk. FIG. 1B shows the waveform of a push-pull signal in the land track.

The header area is repeatedly arranged in every sector of the track. Four PIDs (PID1 through PID4) having the same value are recorded in one header area. The PID1 and the PID2 are arranged to deviate from the center of the track by a certain amount and the PID3 and the PID4 are arranged to deviate from the center of the track to a direction opposite to that of the PID1 and PID2 so that the PIDs can be correctly read even if a laser spot 22 deviates from the center of the track. Also, the arrangements of the PID1 and PID2 and the PID3 and PID4 in the land track are opposite to those in the groove track. The push-pull signal shown in FIG. 1 B can be obtained in the land track.

FIG. 2A shows the physical shape of the groove track in a DVD-RAM disk. FIG. 2B shows the waveform of the push-pull signal in the groove track.

FIG. 3 shows the enlarged header area shown in FIGS. 1A through 2A. In the structure of the header area, the PID1 and PID2 and the PID3 and PID4 are arranged to deviate from the center of the track in opposite directions by a uniform amount. A vfo signal having a specified frequency for synchronizing and detecting ID and an ID signal showing the physical addresses of the sectors are recorded in the respective PIDS. The vfo signal has a recording pattern of 4T (T is a period of the clock signal).

As shown in FIG. 3, the header area is comprised of vfo1 33 and ID1 (PID1) 34, vfo2 35 and ID2 (PiD2) 36, vfo3 37 and ID3 (PID3) 38, and vfo4 39 and ID4 (PID4) 40.

In FIG. 3, when the laser spot passes through the header area of the groove track, a push-pull signal RF_pp shown in FIG. 4A and a sum signal RF sum shown in FIG. 4B are obtained. In FIG. 4A, a vfo1 signal 42 corresponds to the vfo1 signal area 33 of FIG. 3. A vfo3 signal 43 corresponds to the vfo3 signal area 37.

FIG. 5 shows the structure of an apparatus for obtaining the push-pull signal shown in FIG. 4A and the sum signal shown in FIG. 4B. In FIG. 5, reference numeral 50 denotes a photodetector divided into four sections. Reference numerals 52 and 54 denote adders. Reference numeral 56 denotes a calculator.

The apparatus shown in FIG. 5 outputs the sum signal RF-sum of signals detected by light receiving elements A through D of the photodetector divided into four, sum signals V1 and V2 of radial pairs B and C, and A and D of respective light receiving elements, and the push-pull signal RF_pp which is a subtraction signal V2-V1 of V1 and V2.

FIG. 10 shows a conventional technology for compensating for tilt and a method for detecting the amount of tilt by a specific pattern recorded on the track of a disk. The specific pattern coincides with the proceeding direction of the track and the center of the track and is realized in the form of a reference pit A and/or a reference pit B.

It is possible to obtain tilt information by comparing signals reproduced from the reference patterns shown in FIG. 10 with each other and to thus operate a tilt compensating equipment according to the obtained tilt information or to compensate for the signals by changing the equalizer coefficient of the reproducing signal.

The reference patterns shown in FIG. 10 are located in an arbitrary position in the disk and are useful for detecting tangential tilt (tilt in a track direction).

However, in the conventional technology shown in FIG. 10, the length of the reference pattern for detecting the tilt is too short. Another pattern is necessary in order to detect the correct position of the tilt pattern. Also, radial tilt (tilt in a radial direction) cannot be detected. Since the radial tilt is larger than the tangential tilt in practice, the reference patterns are not so useful.

Since it is necessary to precisely manage the servo for the recording/reproducing apparatus to maintain an optimal recording/reproducing state, it is necessary to manage the servo error signal in high resolution.

However, the precision of the servo error signal varies depending on the disk or the reproducing apparatus. Accordingly, it is difficult to precisely manage the servo.

SUMMARY OF THE INVENTION

It is an objective of the present invention to provide an apparatus for the recording and/or reproduction of data from a disk in which a recording area is divided into sectors, each sector has a header for indicating an address, each header has a first header and a second header which are recorded to deviate from a center of a track in opposite directions, and the first header and the second header have address areas in which address signals recorded in the address area are recorded, the apparatus comprising: a reproducing signal generator, including a photodetector having radial pairs of detecting elements, which generates a

reproducing signal including sum signals V1 and V2 of the radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements, from an optical signal reflected from the disk; a header area detector which generates a header area signal comprising a header area from the reproducing signal received from the reproducing signal generator; a first synchronous signal level detector which receives the reproducing signal from the reproducing signal generator and detects a first magnitude Ivfo1 of a first synchronous signal in the first header by being synchronized with the header area signal received from the header area detector; a second synchronous signal level detector which receives the reproducing signal from the reproducing signal generator and detects a second magnitude Ivfo3 of a second synchronous signal in the second header by being synchronized with the header area signal received from the header area detector; and a balance calculator which calculates a balance value K_1, of the magnitude Ivfo1 of the first synchronous signal detected by the first synchronous signal level detector and the magnitude Ivfo3 of the second synchronous signal detected by the second synchronous signal level detector.

Preferably, the apparatus further comprises a comparator which compares the balance value K_1 determined by the balance calculator with a reference value K_o, and determines a difference K_t between the balance value K_1 and the reference value K_o with the reference value K_0 being a balance value measured in a regularized reference state.

In the apparatus, it is preferable that the disk comprises a land track, a groove track, and a wobble for separating the land track from the groove track, and the amount of a detrack is determined by the amount of variation of a wobble signal produced by the wobble in a radial direction. The balance calculator may determine the balance value K_1 to be (Ivfo1 – Ivfo3)/(Ivfo1 + Ivfo3).

It is preferred that the disk comprises a land track and a groove track, and the apparatus further comprises a polarity inverter which inverts a polarity of the difference K_t according to the land/groove tracks; a land/groove detector which receives the reproducing signal provided by the reproducing signal generator, detects the land/groove tracks to generate a detection result, and transmits the detection result to the polarity inverter; and a tilt controller which controls tilt of the disk according to the output of the polarity inverter.

Preferably, the first synchronous signal level detector and the second synchronous signal level detector detect the first and second magnitudes of the first and second synchronous

signals, respectively, from the push-pull signal RF_pp generated by the reproducing signal generator.

It is preferable that the reference value K_0 is a measured balance value when there is no tilt and no detrack of the disk.

Advantageously, the apparatus further comprises a tracking controller which compensates for detrack of the disk according to the output of the polarity inverter.

It is advantageous when the first synchronous signal level detector and the second synchronous signal level detector detect the first and second magnitudes of the first and second of synchronous signals, respectively, from the sum signal RF_sum generated by the reproducing signal generator.

The apparatus further comprises: a mirror area signal generator which generates a mirror area signal indicating a mirror area from the sum signal RF_sum in the reproducing signal provided by the reproducing signal generator; and a mirror signal level detector which receives the sum signal RF_sum in the reproducing signal provided by the reproducing signal generator and detects a level of the mirror area signal by being synchronized with the mirror area signal generated by the mirror area signal generator, wherein the balance calculator determines the balance value K_1 based upon the first magnitude Ivfo1 of the first synchronous signal detected by the first synchronous signal level detector, the second magnitude Ivfo3 of the second synchronous signal detected by the second synchronous signal level detector, and the mirror signal level. The balance calculator may determine the balance value K_1 to be (Ivfo1 – Ivfo3)/Io

In another form of the present invention, there is provided an apparatus for recording data on and/or reproducing data from a disk, where the disk is divided into sectors, each sector having a header for indicating an address, wherein each header has a first header and a second header which are recorded to deviate from a center of a track in opposite directions, and the first header and the second header have address areas in which address signals of the sectors are recorded and synchronous signal areas in which synchronous signals for detecting the address signals recorded n the address area are recorded, comprises: a detector which detects a first magnitude I1 of a first synchronous signal in the first header and a second magnitude I2 of a second synchronous signal in the second header; a calculator which calculates a balance value K_1 of I1 and I2.

Preferably, the apparatus further comprises: a reproducing signal generator, including a photodetector having pairs of detecting elements detecting an optical signal reflected off the disk, which generates a reproducing signal including sum signals V1 and V2 of radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements, from an optical signal reflected from the disk; a header area detector which generates a header area signal comprising a header area from the reproducing signal; and wherein said header area detector receives the reproducing signal and is synchronized with the header area signal.

The reproducing signal may include sum signals V1 and V2 of radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements.

Preferably, the apparatus further comprises a comparator which determines a difference K_t between the balance value K_1 and a reference value K_0; a land track and a groove track, and the apparatus further comprises a polarity inverter which inverts a polarity of a difference K_t according to the land and groove tracks.

It is advantageous when the apparatus further comprises a tilt controller which controls tilt of the disk according to the output of said polarity inverter; a photodetector having pairs of detecting elements detecting an optical signal reflected off the disk, which generates a reproducing signal including a sum signal RF_sum of the detecting elements; a mirror area signal generator which generates a mirror area signal indicating a mirror area from the sum signal RF_sum; a mirror signal level detector which detects a level of the mirror area signal by being synchronized with the mirror area signal; and wherein said calculator determines the balance value K_1 based on I1, I2 and the mirror signal level.

According to another form of the present invention, there is provided an apparatus to detect a servo error of a recording and/or reproducing apparatus for recording the data on and reproducing data from a disk in a data area of which reference patterns having a uniform size are recorded, the apparatus, comprises: a detector which detects a first magnitude of the reference patterns recorded on at least two positions separated from each other and a second magnitude of a reproducing signal corresponding to the reference patterns; and a comparator which determines the servo error in accordance with a ratio of the first magnitude to the second magnitude.

The disk may be divided into sectors and each reference pattern is a synchronous signal included in a header area in which the addresses of the sector are recorded and includes a land track and a groove track and each reference pattern is a wobble signal for separating the land track from the groove track in a radial direction of the disk.

In a final form of the present invention, there is provided an apparatus to detect a tilt error of an apparatus for reproducing data from an optical disk in accordance with a subtraction signal RF_pp having a first reference signal and a second reference signal which are recorded to deviate from a center of a track in opposite directions and which have the same pattern, the apparatus comprises: a detector to detect a first level Ivfo1 of the first reference signal and a second level Ivfo3 of the second reference signal from a subtraction signal RF_pp reproduced from the optical disk;a comparator to determine a balance value K_1 according to the following equation: $K_1 = (Ivfo1-Ivfo3)/(Ivfo1+Ivfo3)$, and determine the tilt error based upon the balance value K_1.

Preferably, the disk is divided into sectors having a predetermined length on the track, each sector comprises the first and second reference signals, and wherein the comparator further determines tilt error by averaging balance values obtained from adjacent one of the sectors.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objectives and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1A shows the physical shape of a land track;
FIG. 1B shows the waveform of a push-pull signal in the land track;
FIG. 2A shows the physical shape of a groove track;
FIG. 2B shows the waveform of a push-pull signal in the groove track;
FIG. 3 shows an enlarged header area shown in FIGS. 1A and 2A;
FIGs. 4A and 4B show a push-pull signal and a sum signal which are obtained when a laser spot passes through the header area of the groove track in FIG. 3;
FIG. 5 shows the structure of an apparatus for obtaining the reproducing signal shown in FIG. 4;

FIG. 6 is a block diagram showing the structure of an embodiment of an apparatus for detecting a servo error according to the present invention;

FIGs. 7A through 7E show waveforms during the operation of the apparatus shown in FIG. 6;

FIG 8 is a block diagram showing the structure of another embodiment of the apparatus for detecting the servo error according to the present invention;

FIGs. 9A through 9B show waveforms during the operation of the apparatus shown in FIG. 8;

FIG. 10 shows a conventional technology for correcting tilt;

FIG. 11 is a graph showing the relationship between radial tilt and a balance value K in the method and apparatus according to the present invention; and

FIG. 12 is a graph showing the relationship between detrack and the balance value K in the method and apparatus according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the structure and operation of the present invention will be described in detail with reference to the attached drawings

For example, in a push-pull signal, the ratio of the magnitude of the signal PID1 and PID2 to the magnitude of the signal PID3 and PID4 varies by up to 30%, depending on the disk. When such a signal is used as a reference signal for controlling a servo, it is difficult to precisely manage the servo and maintain optimal recording/reproducing states.

In the method for detecting the servo error according to the present invention, a servo error is detected by the ratio of the magnitude of reference patterns regularly recorded on a disk to the magnitude of a reproducing signal corresponding to the reference patterns. Reference patterns could include a synchronous signal recorded in a header area and a wobble signal recorded in the direction of the track of a disk.

First, a method for detecting the servo error using the synchronous signal recorded in the header area will be described. When the optical axis of a laser spot is vertical to the header area, namely, when tilt in a radial direction does not occur, the magnitude (Ivfo1) of a detected vfo1 signal is approximately equal to the magnitude (Ivfo3) of a vfo3 signal. However, in the case that tilt or detrack occurs, when either the Ivfo1 or the Ivfo3 becomes large, the other becomes small.

This is because the intensity of light reflected from the PID1 and PID2 and the PID3 and PID4, which are arranged to deviate from the center of the track in opposite directions, varies in relation to the tilt of the disk although the light spot tracks the center of the track. When the disk is tilted to the inner side, the intensity of light reflected from an upper header (a peak header) is larger than that reflected from a lower header (a bottom header) as shown in FIGS. 1A through 2A.

Accordingly, the ratio of the magnitude lvfo1 of the vfo1 signal to the magnitude lvfo3 of the vfo3 signal varies. Also, the ratio of the magnitude lvfo2 of a vfo2 signal to the magnitude lvfo6 of a vfo4 signal varies.

In order to detect the degree to which the magnitude ratio varies, a signal recorded at a uniform level should be used. Since a vfo signals have uniform levels and frequencies, the vfo signals are suitable for this purpose. Also, it is easier to detect the magnitude of the vfo1 and vfo3 signals than that of the vfo2 and vfo4 signals.

Here, when the magnitudes of the synchronous signals detected in vfo1 and vfo3 areas are lvfol and lvfo3, a balance value K is defined as follows.

$$K=(lvfo_1 - lvfo_3)/(lvfo_1 + lVfo_3) \quad ...(1)$$

or

$$K=(lvfo_1 - lvfo_3)/Io \quad ... (2)$$

wherein, Io is the magnitude of the sum signal RF_sum in the mirror area.

In Equations 1 and 2, the balance value is calculated using the magnitude of the synchronous signals detected from the areas vfo1 and vfo3. While it is possible to calculate the balance value using the magnitude of the synchronous signals detected from the areas vfo2 and vfo4, it is easier to detect the synchronous signals from the areas vfo1 and vfo3 than from the areas vfo2 and vfo4. Also, it is possible to use the value obtained by the combination of the synchronous signals detected in the areas vfo1 and vfo2 and the value obtained by the combination of the synchronous signals detected in the areas vfo3 and vfo4.

When the balance value K obtained in the case that there is no servo error is K_0, and the balance value K obtained in the case that a servo error exists is K_1, the difference between the two values is defined as follows.

$$K_t = K_0 - K_1 \quad \ldots (3)$$

Namely, it is possible to know the direction and magnitude of the servo error according to the value and sign of K_t.

Here, K_0 may be the value measured in a state where there is no servo error, a default value determined by the system controller of a recording/reproducing apparatus, or a value measured in a reference state determined by the system.

In the land track and the groove track, the polarity of K_1 should vary in order to calculate K_t correctly since the position of PID1 and PID2 and the position of PID3 and PID4 are inversed.

A method for detecting the servo error of the disk using the wobble signal will now be described. Wobble is formed in the land track and the groove track in the DVD-RAM disk. The wobble is in the form of a sinusoidal wave formed on the side wall of the track.

When the disk is tilted in a radial direction, the wobble signal is tilted in the radial direction. Namely, the magnitude of the wobble signal varies between two arbitrary points separated from each other in the radial direction. Therefore, it is possible to detect tilt by detecting the amount of change of the wobble signal in the radial direction.

FIG. 6 is a block diagram showing the structure of a preferred embodiment of the apparatus for detecting the servo error signal according to the present invention. The apparatus shown in FIG. 6 includes a reproducing signal generator 62, a header area detector 64, a first synchronous signal level detector 66, a second synchronous signal level detector 68, a balance calculator 70, a comparator 72, a land/groove detector 76, a tilt controller 74, a polarity inverter 78, and a detrack compensator 80.

The reproducing signal generator 62 generates a sum signal RF_sum, sum signals V1 and V2 of radial pairs, and a push-pull signal RF_pp obtained by subtracting V1 from V2. The reproducing signal generator 62 includes the photodetector divided into four and a calculator as shown in FIG. 5.

The header area detector 64 generates header area signals (a header area signal 1 and a header area signal 2) showing the header area from the reproducing signal. Here, the header area signal 1 notifies the PID1 and PID2 areas. The header area signal 2 notifies the PID3 and PID4 areas. Since the header area has an envelope larger than that of the data area, it is possible to obtain a header area signal showing the header area using both an envelope detector for detecting the envelope of the reproducing signal and the comparator.

The first synchronous signal level detector 66 synchronized with the header area signal 1 generated by the header area detector 64 detects the magnitude Ivfo1 of the vfo1 signal shown in FIG. 4. To be specific, a first enable signal (enable 1) having a predetermined width and separated from the starting point of the header area signal 1 by a predetermined distance is generated. After gating the reproducing signal by the first enable signal (enable 1), the magnitude Ivfo1 of the vfo1 signal is detected by detecting the peak-to-peak value of the reproducing signal.

The second synchronous signal level detector 68 synchronized with the header area signal 2 generated by the header area detector 64 detects the magnitude of the vfo3 signal shown in FIG. 4. To be specific, the magnitude Ivfo3 of the vfo3 signal is detected by generating a second enable signal (enable 2) having a predetermined width and separated from the starting point of the header area signal 2, gating a reproducing signal by the second enable signal (enable 2), and detecting the peak-to-peak value of the gated reproducing signal.

The balance calculator 70 calculates the ratio of the magnitude Ivfo1 of the vfo1 signal detected by the first synchronous signal level detector 66 to the magnitude Ivfo3 of the vfo3 signal detected by the second synchronous signal level detector 68 as shown in Equation 1. Here, the balance calculator 70 can output the mean value of the balance values obtained from several successive sectors in the radial or tangential direction.

The comparator 72 compares the balance value K_1 calculated by the balance calculator 70 with a predetermined reference value K_0 and outputs the difference between the two values K_t as shown in Equation 3. Here, K_0 may be a value measured in a state where there is no tilt, a default value determined by the system controller of the recording/reproducing apparatus, or a value measured in the reference state determined by the system.

The land/groove detector 76 receives the reproducing signal and detects whether the current track is the land track or the groove track. In the push-pull signal of the land track,

the magnitude of the PID1 and PID2 is smaller than that of PID3 and PID4 as shown in FIG. 1B. In the push-pull signal of the groove track, the magnitude of PID1 and PID2 is smaller than the magnitude of the PID3 and PID4. The land/groove detector 76 discriminates the land track from the groove track using the above.

The polarity inverter 78 inverts the polarity of the subtraction value K_t output from the comparator 72 according to the result detected by the land/groove detector 76.

The balance value can be used in order to compensate for tilt.

The tilt controller 74 controls the tilt of the disk according to the subtraction value K_t the polarity of which is inverted and which is output from the polarity inverter 78. Since the sign and magnitude of the subtraction value K_t show the direction and magnitude of the tilt, the tilt of the disk is controlled by feeding back the sign and the magnitude of the subtraction value K_t.

The balance value can be used in order to correct detrack.

The detrack compensator 80 controls the detrack of the disk according to the subtraction value K_t the polarity of which is inverted and which is output from the polarity inverter 78. Since the sign and magnitude of the subtraction value K_t shows the direction and magnitude of the detrack, the detrack of the disk is controlled by feeding back the subtraction value K_t.

FIG. 7 shows the waveforms of the operation of the apparatus shown in FIG. 6. FIG. 7A shows the waveform of the push-pull signal generated by the reproducing signal generator 62. FIGS. 7B and 7C show the waveforms of the header area signal 1 and the header area signal 2, respectively, generated by the header area signal generator. FIGs. 7D and 7E show the waveforms of the first enable signal (enable 1) and the second enable signal (enable 2) used by the first synchronous signal level detector 66 and the second synchronous signal level detector 68.

FIG. 8 is a block diagram showing the structure of another embodiment of the apparatus for generating the servo error signal according to the present invention. The apparatus shown in FIG. 8 is similar to the apparatus shown in FIG. 6 except that the apparatus includes a mirror area signal generator 86 and a mirror signal level detector 88. Therefore, the same

reference numerals are used for the same members and a detailed description thereof is omitted.

The mirror area signal generator 86 generates a mirror area signal showing a mirror area from the sum signal RF_sum provided by the reproducing signal generator 62. In the push-pull signal RF_pp, since the mirror signal becomes zero, it is not possible to obtain the mirror area signal by the push-pull signal RF_pp.

It is possible to generate the mirror area signal by the envelope detector and the comparator since the mirror signal has a much lower envelope than the signals of the data area and the header area.

The mirror signal level detector 88 detects the level of the mirror signal from the sum signal RF_sum by the mirror area signal generated by the mirror area signal generator 86. The mirror signal level detector 88 generates a third enable signal (enable 3) having a predetermined period by the mirror area signal generated by the mirror area signal generator, gates the sum signal RF_sum by the third enable signal (enable 3), and detects the peak-to-peak value of the gated sum signal RF_sum.

The balance calculator 72 calculates the balance value K_1 as shown in Equation 2 by the level lvfo1 of the vfo1 signal detected by the first synchronous signal level detector 66, the level lvfo3 of the vfo3 signal, detected by the second synchronous signal level detector 68, and the mirror signal level lo detected by the mirror signal level detector 88. Here, the balance calculator 72 can output the mean value of the balance values obtained from several successive sectors in the radial or tangential direction.

FIGS. 9A and 9B show waveforms during the operation of the apparatus shown in FIG. 8. FIG. 9A shows the waveform of the mirror area signal output from the mirror area signal generator 86. FIG. 9B shows the waveform of the third enable signal (enable 3).

According to the present invention, R is possible to use the push-pull signal RF_pp, the sum signals V1 and V2 of the radial pairs, and the sum signal RF_sum for detecting the servo error since the servo error is detected by the balance value of the synchronous signals. For example, when the push-pull signal RF_pp is used, it is possible to compensate for tilt in the radial direction. When the sum signal RF_sum is used, R is possible to compensate for tilt in the tangential direction.

FIG. 11 is a graph showing the relationship between the radial tilt and the balance value K in the method and apparatus according to the present invention. In FIG. 11, the horizontal axis denotes radial tilt-values and the vertical axis denotes balance values K. In FIG. 11, the graph marked with ▲ shows a case where the sum signal RF_sum and the balance value according to Equation 1 are used. The graph marked with ▼ shows a case where the sum signal RF_sum and the balance value according to Equation 2 are used. The graph marked with ● shows a case where the push-pull signal RF_sum and the balance value according to Equation 2 are used. The graph marked with ■ shows a case where the pushpull signal RF_pp and the balance value according to Equation 1 are used.

As shown in FIG. 11, the radial tilt is best described by the case marked with ■ where the push-pull signal RF_pp and the balance value according to Equation 1 are used. The case marked with ● where the push-pull signal RF-PP and the balance value according to Equation 2 are used is also useful for describing the radial tilt.

Therefore, it is possible to determine the tilt by the values according to Equations 1 and 2 using the push-pull signal RF_pp.

FIG. 12 is a graph showing the relationship between the detrack and the balance value K in the method and apparatus according to the present invention. In FIG. 12, the horizontal axis denotes the amount of the detrack. The vertical axis denotes the balance value K. In FIG. 12, the graph marked with ▲ shows a case where the sum signal RF-sum and the balance value according to Equation 1 are used. The graph marked with ▼ shows a case where the sum signal RF sum and the balance value according to Equation 2 are used. The graph marked with ● shows a case where the push-pull signal RF_pp and the balance value according to Equation 2 are used. The graph marked with ■ shows a case where the push-pull signal RF_pp and the balance value according to Equation 1 are used.

As shown in FIG. 12, the graph marked with ▲ which shows the case where the sum signal RF-sum and the balance value according to Equation 1 is most affected by the detrack The graph marked with ■ which shows the case where the push-pull signal RF_pp and the balance value according to Equation 1 is least affected by the detrack.

Therefore, it is possible to determine the detrack by the value according to Equation 1 or 2 using the sum signal RF-sum.

As shown in FIGS. 11 and 12, it is possible to most effectively detect the amount of tilt when the push-pull signal RF_pp and the balance value according to Equation 1 are used.

The quality of the servo error signal varies according to the quality of the disk and the conditions of the system. However, when the value of the servo error signal is not restricted to some degree, it is not possible to recognize the PID or it is difficult to stably manage the servo. Therefore, in the disk, the value K_0 is preferably managed to maintain a prescribed level.

Accordingly, in the present invention, it is suggested that the value K_0 be restricted to ±0.1. This value is required to normally reproduce the PID when a standard amount of tilt ±0.35° is given. Also, the allowance range of the track control is considered

Also, it is necessary to restrict the value K_t to no more than a predetermined value to precisely control the servo in the apparatus for reproducing data from the disk. When the quality of the servo is not strictly managed when the data is reproduced, R is not possible to obtain the PID information.

Therefore, in the present invention, it is suggested that the value K_t be restricted to ±0.1 in the servo operation of the reproducing apparatus.

It is possible to correctly detect the tilt state of the disk without a specific pattern for detecting the servo error by the method for detecting the servo error according to the present invention.

It is possible for the recording/reproducing apparatus to stably control the servo and to maintain an optimal recording/reproducing state since the apparatus for generating the servo error signal according to the present invention correctly detects the servo error state of the disk.

It is possible for the recording/reproducing apparatus to stably control the servo and to maintain the optimal recording/reproducing state since it is possible to strictly manage the level of the servo error signal which is the basis of controlling the servo by the disk according to the present invention.

CLAIMS

1. An apparatus for recording data on and/or reproducing data from a disk in which a recording area is divided into sectors, each sector has a header for indicating an address, each header has a first header and a second header which are recorded to deviate from a center of a track in opposite directions, and the first header and the second header have address areas in which address signals recorded in the address area are recorded, the apparatus comprising:

a reproducing signal generator, including a photodetector having radial pairs of detecting elements, which generates a reproducing signal including sum signals V1 and V2 of the radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements, from an optical signal reflected from the disk;

a header area detector which generates a header area signal comprising a header area from the reproducing signal received from the reproducing signal generator;

a first synchronous signal level detector which receives the reproducing signal from the reproducing signal generator and detects a first magnitude lvfo1 of a first synchronous signal in the first header by being synchronized with the header area signal received from the header area detector;

a second synchronous signal level detector which receives the reproducing signal from the reproducing signal generator and detects a second magnitude lvfo3 of a second synchronous signal in the second header by being synchronized with the header area signal received from the header area detector; and

a balance calculator which calculates a balance value K_1, of the magnitude lvfo1 of the first synchronous signal detected by the first synchronous signal level detector and the magnitude lvfo3 of the second synchronous signal detected by the second synchronous signal level detector.

2. The apparatus of claim 1, further comprising a comparator which compares the balance value K_1 determined by the balance calculator with a reference value K_0, and determines a difference K_t between the balance value K_1 and the reference value K_0.

3. The apparatus of claim 2, wherein the reference value K_0 is a balance value measured in a regularized reference state.

4. The apparatus of any one of claims 1 to 3, wherein the disk comprises a land track, a groove track, and a wobble for separating the land track from the groove track, and the amount of a detrack is determined by the amount of variation of a wobble signal produced by the wobble in a radial direction.

5. The apparatus of claim 2 or 3, wherein the balance calculator determines the balance value K_1 to be (lvfo1 – lvfo3)/(lvfo1 + lvfo3).

6. The apparatus of claim 2, wherein the disk comprises a land track and a groove track, and the apparatus further comprises a polarity inverter which inverts a polarity of the difference K_t according to the land/groove tracks.

7. The apparatus of claim 6, further comprising a land/grove detector which receives the reproducing signal provided by the reproducing signal generator, detects the land/groove tracks to generate a detection result, and transmits the detection result to the polarity inverter

8. The apparatus of claim 6 or claim 7, further comprising a tilt controller which controls tilt of the disk according to the output of the polarity inverter.

9. The apparatus of any one of claims 1 to 8, wherein the first synchronous signal level detector and the second synchronous signal level detector detect the first and second magnitudes of the first and second synchronous signals, respectively, from the push-pull signal RF_pp generated by the reproducing signal generator.

10. The apparatus of claim 9, wherein the reference value K_0 is a measured balance value when there is no tilt of the disk.

11. The apparatus of claim 7, further comprising a tracking controller which compensates for detrack of the disk according to the output of the polarity inverter.

12. The apparatus of claim 11, wherein the reference value K_0 is a balance value measured when there is no detrack of the disk.

13. The apparatus of any one of claims 1 to 8, wherein the first synchronous signal level detector and the second synchronous signal level detector detect the first and second

magnitudes of the first and second of synchronous signals, respectively, from the sum signal RF_sum generated by the reproducing signal generator.

14. The apparatus of claim 2, further comprising:

a mirror area signal generator which generates a mirror area signal indicating a mirror area from the sum signal RF_sum in the reproducing signal provided by the reproducing signal generator; and

a mirror signal level detector which receives the sum signal RF_sum in the reproducing signal provided by the reproducing signal generator and detects a level of the mirror area signal by being synchronized with the mirror area signal generated by the mirror area signal generator,

wherein the balance calculator determines the balance value K_1 based upon the first magnitude Ivfo1 of the first synchronous signal detected by the first synchronous signal level detector, the second magnitude Ivfo3 of the second synchronous signal detected by the second synchronous signal level detector, and the mirror signal level.

15. The apparatus of claim 14, wherein the balance calculator determines the balance value K_1 to be (Ivfo1 – Ivfo3)/Io

16. An apparatus for recording data on and/or reproducing data from a disk, where the disk is divided into sectors, each sector having a header for indicating an address, wherein each header has a first header and a second header which are recorded to deviate from a center of a track in opposite directions, and the first header and the second header have address areas in which address signals of the sectors are recorded and synchronous signal areas in which synchronous signals for detecting the address signals recorded n the address area are recorded, comprising:

a detector which detects a first magnitude I1 of a first synchronous signal in the first header and a second magnitude I2 of a second synchronous signal in the second header.

a calculator which calculates a balance value K_1 of I1 and I2.

17. The apparatus of claim 16, further comprising:

a reproducing signal generator, including a photodetector having pairs of detecting elements detecting an optical signal reflected off the disk, which generates a reproducing signal including sum signals V1 and V2 of radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements, from an optical signal reflected from the disk;

a header area detector which generates a header area signal comprising a header area from the reproducing signal; and

wherein said header area detector receives the reproducing signal and is synchronized with the header area signal.

18. The apparatus of claim 16, wherein the reproducing signal includes sum signals V1 and V2 of radial pairs of detecting elements, a sum signal RF_sum of the detecting elements, and a push-pull signal RF_pp of the detecting elements.

19. The apparatus of claim 16, further comprising a comparator which determines a difference K_t between the balance value K_1 and a reference value K_0.

20. The apparatus of claim 19, wherein the disk further comprises a land track and a groove track, and the apparatus further comprises a polarity inverter which inverts a polarity of a difference K_t according to the land and groove tracks.

21. The apparatus of claim 20, further comprising a tilt controller which controls tilt of the disk according to the output of said polarity inverter.

22. The apparatus of claim 16, further comprising:

a photodetector having pairs of detecting elements detecting an optical signal reflected off the disk, which generates a reproducing signal including a sum signal RF_sum of the detecting elements;

a mirror area signal generator which generates a mirror area signal indicating a mirror area from the sum signal RF_sum;

a mirror signal level detector which detects a level of the mirror area signal by being synchronized with the mirror area signal; and

wherein said calculator determines the balance value K_1 based on 11, 12 and the mirror signal level.

23. An apparatus to detect a servo error of a recording and/or reproducing apparatus for recording the data on and reproducing data from a disk in a data area of which reference patterns having a uniform size are recorded, the apparatus, comprising:

a detector which detects a first magnitude of the reference patterns recorded on at least two positions separated from each other and a second magnitude of a reproducing signal corresponding to the reference patterns; and

a comparator which determines the servo error in accordance with a ratio of the first magnitude to the second magnitude.

24. The apparatus of claim 23, wherein the disk is divided into sectors and each reference pattern is a synchronous signal included in a header area in which the addresses of the sector are recorded.

25. The apparatus of claim 23, wherein the disk includes a land track and a groove track and each reference pattern is a wobble signal for separating the land track from the groove track in a radial direction of the disk.

26. An apparatus to detect a tilt error of an apparatus for reproducing data from an optical disk in accordance with a subtraction signal RF_pp having a first reference signal and a second reference signal which are recorded to deviate from a center of a track in opposite directions and which have the same pattern, the apparatus comprising:

a detector to detect a first level Ivfo1 of the first reference signal and a second level Ivfo3 of the second reference signal from a subtraction signal RF_pp reproduced from the optical disk;

a comparator to determine a balance value K_1 according to the following equation:

$$K_1 = (Ivfo1-Ivfo3)/(Ivfo1+Ivfo3),$$ and

determine the tilt error based upon the balance value K_1.

27. The apparatus of claim 26, wherein the disk is divided into sectors having a predetermined length on the track, each sector comprises the first and second reference signals, and wherein the comparator further determines tilt error by averaging balance values obtained from adjacent one of the sectors.