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TITLE OF THE INVENTION

Method and Apparatus for Measuring Characteristics of Optical Pickup

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a method and apparatus for measuring characteristics of optical pickup.

Description of the Related Art

There has hitherto been known an apparatus for measuring characteristics of the optical pickup used in an optical disc drive. The apparatus for measuring characteristics of the optical pickup is used in, for example, an optical pickup shipment inspection or acceptance inspection and is conducted for inspecting whether or not the optical pickup meets the prescribed specifications.

Among inspection items for the inspection device for an optical pickup, there is an inspection item of measurement of an amplitude of RF signals (playback signals of an optical disc).

As a system for measuring the amplitude of the RF signals, there is known a system of employing an analog peak-holding circuit. In this system, the maximum and minimum peak values of the RF signals are detected by respective analog peak-holding circuits, and the peak-to-peak voltage therebetween is detected to measure the amplitude of the RF signals. However, if the amplitude of the RF signals is measured by the analog peak-holding circuit, only the maximum and minimum peak values in a

pre-set time period can be found, while it is difficult to measure the amplitude of the RF signal waveform on the period basis.

On the other hand, there is known a system employing a digital processing circuit as the system for measuring the amplitude of the RF signals. In this system, the RF signals are converted into digital signals at a pre-set sampling interval, and the totality of locally maximum and locally minimum peak values are found by digital processing to measure the amplitude of the period-based RF signal waveform. In this system, the period-based amplitude of the RF signals can be measured by diminishing the sampling interval for analog/digital conversion to a value sufficiently smaller than the clock frequency of the RF signals.

However, if the locally maximum and locally minimum peak values are found by digital processing, it is difficult to achieve correct measurement of the period-based amplitude of the RF signal waveform due to enhanced sensitivity to noise.

For example, it is assumed that the detected RF signals are of a waveform as shown in Fig.1A. If small noise such as is shown in Fig.1B is contained in the normal RF signal waveform, peak values of the noise are detected on digital processing.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and apparatus for measuring characteristics of optical pickup whereby the correct amplitude of the RF signal waveform can be measured.

In one aspect, the present invention provides an apparatus for measuring

characteristics of the optical pickup adapted for illuminating the laser light on an optical disc to detect the reflected laser light to detect the information recorded on an optical disc, including means for measuring characteristics of RF signals by sampling RF signals outputted by the optical pickup at a pre-set interval. The measuring means removes the waveform having an amplitude not larger than the amplitude of the waveform of the shortest period to measure the characteristics of the RF signals.

In another aspect, the present invention provides a method for measuring characteristics of the optical pickup adapted for illuminating the laser light on an optical disc to detect the reflected laser light to detect the information recorded on an optical disc, including sampling the RF signals outputted by the optical pickup at a pre-set interval, and removing the waveform having an amplitude not larger than a pre-set proportion with respect to the amplitude of the waveform of the shortest period to measure characteristics of the RF signals.

According to the present invention, the waveform having an amplitude not larger than the pre-set proportion with respect to the amplitude of the waveform of the shortest period is removed to measure the characteristics of the RF signals. According to the present invention, since the amplitude of the waveform of the shortest period is larger by not less than 30% with respect to the average amplitude of the RF signals or with respect to the amplitude of the directly previously sampled RF signals, the characteristics of the RF signals are measured on removing the waveform having the amplitude of, for example, not larger than 30%.

Thus, according to the present invention, the waveform having an amplitude not larger than a pre-set proportion of the amplitude of the waveform of the shortest waveform is removed in the measurement of the characteristics of the RF signals, thus enabling accurate measurement of the waveform of the RF signals.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A shows RF signals obtained on sampling by a conventional measurement apparatus for measuring the characteristics of a conventional optical pickup.

Fig. 1B shows the noise contained in the RF signals shown in Fig. 1A.

Fig. 2 is a block diagram showing an apparatus for measuring characteristics of the optical pickup embodying the present invention.

Fig. 3 shows an illustrative photodetector provided in an optical pickup being measured by the apparatus for measuring characteristics of the optical pickup shown in Fig. 2.

Fig. 4 is a flowchart showing the processing contents of the apparatus for measuring characteristics of the optical pickup.

Fig. 5 shows sampled RF signals.

Fig. 6 shows peak values of the sampled RF signals shown in Fig. 5.

Fig. 7 illustrates the peak-to-peak voltage of the RF signals shown in Fig. 6.

Fig. 8 shows a peak value to be removed as a noise component.

Fig. 9 shows another peak value to be removed as a noise component.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, preferred embodiments of the present invention will be explained in detail.

Fig.2 shows a block diagram of an apparatus for measuring the characteristics of an optical pickup embodying the present invention.

The apparatus 1 for measuring characteristics of an optical pickup, embodying the present invention, measures the amplitude of the RF signal waveform of the optical pickup used in an optical disc drive. In the present specification, the amplitude of the RF signal waveform means the peak-to-peak voltage within a given waveform contained in the RF signals reproduced from the optical disc. The present apparatus 1 for measuring characteristics of the optical pickup measures the amplitude of the RF signal waveform period-by-period.

The optical pickup 2 is an object of measurement by the apparatus 1 for measuring characteristics of the optical pickup, and includes a laser diode 2a, a beam splitter 2b, an objective lens 2c, a photodetector 2d, a focussing actuator 2e and a tracking actuator 2f.

The apparatus 1 for measuring characteristics of the optical pickup includes an optical disc 3, irradiated with the laser light emitted by the optical pickup 2, a rotationally driving unit 4 for rotationally driving the optical disc 3, and a matrix circuit 5, fed with an output of the photodetector 2d owned by the optical pickup 2 to output signals such as playback signals (RF signals), focussing error signals (FE signals) and tracking error signals (TE signals).

The apparatus 1 for measuring characteristics of an optical pickup also includes a servo control circuit 6 for servo controlling for playback driving of the optical disc 3 based on an output of the matrix circuit 5, a playback signal processing circuit 7 for binary-coding, demodulation or error correction of the RF signals from the matrix circuit 5, and a control circuit 8 for rotational driving control of the optical disc 3 and control of various circuits, such as various servo controls and for measurement of characteristics of the RF signals of the optical pickup 2.

The optical pickup 2 may be mounted or dismounted with respect to the apparatus 1 for measuring characteristics of an optical pickup. This optical pickup 2 converges the laser light radiated from the laser diode 2a via the beam splitter 2b and the objective lens 2c on the optical disc 3. The optical pickup 2 forms an image of the reflected light from the optical disc 3 on the photodetector 2d. The photodetector 2d of the optical pickup 2 is the photo-electric transducer as described above and converts the imaged reflected light into electrical signals. The focussing actuator 2e of the optical pickup 2 is responsive to the driving voltage routed from the focussing driver 6 to shift the objective lens 2c along the optical axis of the laser light illuminated on the optical disc 3 in order to bring the focussing point of the laser light into coincidence with the recording surface of the optical disc 3. Also, the tracking actuator 2f of the optical pickup 2 is responsive to the driving voltage routed from the servo controller 6 to shift the objective lens 2c along the radius of the optical disc 3 to shift the laser light to a pre-set track on the optical disc 3.

The optical pickup 2 includes plural photodetectors, an example of which is shown in Fig.2.

The optical pickup 2 includes four photodetectors A to D, arrayed in a 2-by-2 matrix configuration, and photodetector E, F for side spot detection on both sides of the photodetector A to D, as shown in Fig.3. These photodetector A to F are used in, for example, an optical pickup of the so-called three-spot system adapted for radiating three laser light beams to the optical disc. On the photodetectors A to D is illuminated a main beam as a center light beam in the three-spot system. That is, the reflected light from, for example, recording pits formed in the recording track of the optical disc is illuminated on the photodetectors A to D. Also, the photodetectors E, F are provided on both radial sides of radial direction of the disc with respect to the photodetector A to D. The photodetectors are illuminated with side beams in the three-spot system. The photodetectors E, F are illuminated by the light reflected from the track edge of the light reflecting portion 3.

The photodetectors A to F convert the light volumes of the reflected light into signals A to F, respectively. The optical pickup 2 routes these signals A to F to the matrix circuit 5.

The optical disc 3 is set on the rotationally driving device 4 of the apparatus 1 for measuring characteristics of an optical pickup, and is run in rotation by this rotationally driving device 4. The optical disc 3 is also used as a reference for the apparatus 1 for measuring characteristics of the optical pickup. That is, the apparatus

1 for measuring characteristics of an optical pickup measures the characteristics of the optical pickup 2 based on the information derived from the reflected light from the optical disc 3 used as this reference. That is, the apparatus 1 for measuring characteristics of the optical pickup measures characteristics of the optical pickup 2 based on the information obtained from the reflected light of the optical disc 3 used as this reference.

The matrix circuit 5 is fed with signals A to F, outputted by the photodetectors A to F of the optical pickup, to generate playback (RF) signals, focussing error (FE) signals and tracking error (TE) signals. The matrix circuit 5 generates the RF, FE and TE signals, from the signals A to D, as described above. That is, the matrix circuit 5 calculates $A+B+C+D$ from the signals A to D to generate RF signals. The matrix circuit 5 also outputs FE signals in accordance with the astigmatic method. That is, the matrix circuit 5 calculates $(A+C) - (B+D)$, from the signals A to D to output the calculated result as FE signal. On the other hand, the matrix circuit 5 calculates $E - F$ from the signals E and F to output the calculated result as TE signal.

The servo control circuit 6 is fed with the FE signals from the matrix circuit 4. After filtering the FE signals in a pre-set manner, the servo control circuit 6 routes a signal of a control volume which will reduce the FE signals to zero to the focussing actuator 2e of the optical pickup 2. Thus, the servo control circuit 6 controls the laser light radiated from the optical pickup 2 so that a just-focus state will be reached on the recording surface of the optical disc 3.

The servo control circuit 6 is fed with the TE signals from the matrix circuit 5. After filtering the FE signals in a pre-set manner, the servo control circuit 6 routes signal of a control volume which will reduce the TE signals to zero to the tracking actuator 2f of the optical pickup 2 via the tracking driver 8. Thus, the servo control circuit 6 controls the laser light radiated from the optical pickup 2 so that a just-track state will be reached on the recording track of the optical disc 3. It is also possible for this servo control circuit 6 to perform skew servo control to control the tilt of the optical disc 3, in addition to the focussing servo control and the tracking servo control as described above.

The playback signal processing circuit 7 is fed with RF signals from the matrix circuit 5. The playback signal processing circuit 7 performs filtering, binary-coding, demodulation and error correction on the supplied Rf signals to output playback data obtained from the optical disc 3.

The control circuit 8 performs control operations for respective circuits, such as rotational driving control of the optical disc 3 and a variety of servo control operations. The control circuit 8 includes an analog/digital converter 8a, an internal memory 8b, a digital processing circuit 8c etc and, by these circuits, measures the characteristics of RF signals supplied from the matrix circuit 5.

The processing for measuring the amplitude characteristics of the RF signal waveform of the optical pickup 2 by the present apparatus 1 for measuring characteristics of the optical pickup is hereinafter explained.

The apparatus 1 performs the processing of steps S1 to S6 shown in Fig.4 to measure the amplitude of the RF signal waveform.

First, the apparatus 1 for measuring characteristics of the optical pickup performs sampling of the RF signals, as shown in Fig.5 (step S1).

Specifically, the control circuit 8 routes various servo control start commands, such as those for focussing servo control and tracking servo control, to the servo control circuit 6, to start reproduction of the optical disc 3. The analog/digital converter 8a of the control circuit 8 analog/digital converts RF signals supplied from the matrix circuit 5 to store the converted digital data in the internal memory 8b. At this time, the analog/digital converter 8a effects analog/digital conversion at a sampling rate sufficiently smaller than the clocks of the RF signals.

The apparatus 1 for measuring characteristics of the optical pickup then detects locally maximum and locally minimum peak values of the sampled RF signals, as shown in Fig.6 (step S2).

The locally maximum values can be detected by chronologically analyzing the sampling data stored in the internal memory 8b to find sampling data larger in magnitude than the temporally directly previous data and larger in magnitude than the temporally directly posterior data. The digital processing circuit 8c finds out this locally maximum peak value to store the thus found locally maximum peak value in the internal memory 8b.

The locally minimum values can be detected by chronologically analyzing the

sampling data stored in the internal memory 8b to find sampling data smaller in magnitude than the temporally directly previous data and smaller in magnitude than the temporally directly posterior data. The digital processing circuit 8c finds out this locally minimum peak value to store the thus found locally minimum peak value in the internal memory 8b.

The apparatus 1 for measuring characteristics of the optical pickup detects the peak-to-peak voltage V_{p-p} between temporally consecutive locally maximum and locally minimum values, as shown in Fig.7 (step S3).

Specifically, the digital processing circuit 8c sequentially chronologically analyzes the locally maximum and locally minimum values, stored in the internal memory 8b, and finds the differential voltage between temporally neighboring locally maximum and locally minimum values, to store the differential voltage between the temporally neighboring locally maximum and locally minimum values as the peak-to-peak voltage V_{p-p} chronologically in the internal memory 8b.

The apparatus 1 for measuring characteristics of the optical pickup then detects the noise components based on the peak-to-peak voltage V_{p-p} as found at step S3 (step S4).

Specifically, the digital processing circuit 8c chronologically analyzes the peak-to-peak voltage V_{p-p} stored in the internal memory 8b to verify whether or not the peak-to-peak voltage V_{p-p} has a proportion not larger than pre-set proportion with respect to the temporally directly previous peak-to-peak voltage V_{p-p} . The waveform containing

the peak-to-peak voltage V_{p-p} not larger than the pre-set proportion is deemed to be a noise component.

The above-mentioned pre-set proportion, representing the threshold value for verifying the noise component, is determined on the basis of the amplitude of the waveform of the shortest period of the RF signals, for the following reason:

In general, the shortest period and the longest period of the RF signals reproduced from the optical disc are prescribed in the relevant standard. In the case of a compact disc, for example, signals having a period ranging from $3T$ to $11T$, where T is the clock period of the RF signals, are prescribed to be reproduced. Thus, the shortest period and the longest period are $3T$ and $11T$, respectively. The waveform of the shortest period usually has the smallest amplitude among the waveforms of the respective periods. Thus, by setting the above-mentioned pre-set proportion of removal of the noise component based on the amplitude of the waveform of the shortest period, it is possible to remove the large noise contained in the RF signals without judging the waveform of the shortest period as the noise.

In an optical disc, such as a compact disc, it is statistically known that the amplitude of the waveform of the shortest period (the waveform of $3T$) is 30 to 60% in magnitude of the average amplitude of the RF signals. Therefore, by setting the above-mentioned pre-set proportion, representing a threshold value of removal of a component as being the noise, to 30% or less, for example, to 5 to 30%, it is possible to remove the noise without removing the waveform of the shortest period.

It is noted that, although the noise is detected at this step S4 by checking whether or not the peak-to-peak voltage V_{p-p} stored in the internal memory 8b is not larger than the temporally directly previous peak-to-peak voltage V_{p-p} , the peak-to-peak voltage V_{p-p} not larger than a pre-set proportion of the average value of the totality of temporally past peak-to-peak voltages V_{p-p} may be deemed to be the noise, or the peak-to-peak voltage V_{p-p} not larger than a pre-set proportion of the average values of several temporally past peak-to-peak voltages V_{p-p} may be deemed to be the noise.

The apparatus 1 for measuring characteristics of the optical pickup then removes the locally maximum and locally minimum peak value judged to be noise component at step S4 (step S5).

An illustrative removing operation is explained with reference to Figs.8 and 9. Meanwhile, the removing processing is not limited to the typical operation, now explained, since it suffices if the locally maximum and locally minimum peak values can be removed so that there will be no peak-to-peak voltage V_{p-p} judged to be the noise as a result of the processing of step S4.

For example, it is assumed that, as shown in Fig.8, there is a peak-to-peak voltage $V_{p-p}(n)$ having a proportion not larger than a re-set value with respect to the temporally directly previous peak-to-peak voltage $V_{p-p}(n-1)$ at step S4. First, a temporally later one of the locally maximum value or the locally minimum value, used to find this peak-to-peak voltage $V_{p-p}(n)$, is removed. That is, the peak value not used for finding the peak-to-peak voltage $V_{p-p}(n-1)$ temporally directly previous to the peak-

to-peak voltage $V_{p-p}(n)$ is removed. If one of the locally maximum value and the locally minimum value, used to find the peak-to-peak voltage $V_{p-p}(n)$, is then removed, as shown in Fig.9, the result is the consecutive locally maximum values or the consecutive locally minimum values. Therefore, if there exist the consecutive locally maximum values, the smaller one of the consecutive locally maximum values is removed, whereas, if there exist the consecutive locally minimum values, the larger one of the consecutive locally minimum values is removed. By this processing, it is possible to remove the locally maximum value and the locally minimum value, judged to be noise components.

The apparatus 1 for measuring characteristics of the optical pickup then re-detects the peak-to-peak voltage V_{p-p} between the locally maximum value and the locally minimum value, freed of the noise components (step S6).

Thus, by executing the processing of the steps S1 to S6, the apparatus 1 for measuring characteristics of the optical pickup is able to detect the correct peak-to-peak voltage freed of noise and to measure the amplitude of the RF signal waveform based on this correct peak-to-peak voltage.

The processing of the above steps S1 to S6 can be executed in real-time by processing the respective steps by plural CPUs or DSPs or by parallel processing by a sole CPU.



WHAT IS CLAIMED IS:

1. An apparatus for measuring characteristics of the optical pickup adapted for illuminating the laser light on an optical disc to detect the reflected laser light to detect the information recorded on an optical disc, comprising:

means for measuring characteristics of RF signals by sampling RF signals outputted by said optical pickup at a pre-set interval;

said measuring means removing the waveform having an amplitude not larger than the amplitude of the waveform of the shortest period to measure the characteristics of the RF signals.

2. The apparatus for measuring characteristics of the optical pickup according to claim 1 wherein said measuring means removes the waveform having an amplitude not larger than 30% of the average amplitude of the RF signals.

3. A method for measuring characteristics of the optical pickup adapted for illuminating the laser light on an optical disc to detect the reflected laser light to detect the information recorded on an optical disc, comprising:

sampling the RF signals outputted by said optical pickup at a pre-set interval;
and

removing the waveform having an amplitude not larger than a pre-set proportion with respect to the amplitude of the waveform of the shortest period to measure characteristics of the RF signals.

4. The method for measuring characteristics of the optical pickup according to claim



3 wherein the waveform having an amplitude not larger than 30% of the average amplitude of the RF signals is removed.