

TITLE OF THE INVENTION

Apparatus for Measuring Jitter in Optical Disc

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an apparatus for inspecting the specifications or characteristics of an optical disc and, more particularly, to an apparatus for measuring the jitter in reproduced data of the optical disc.

Description of the Related Art

Up to now, an optical disc, such as CD, is inspected, at the time of fabrication, shipment or product development, as to whether or not the manufactured optical disc meets prescribed specifications. Among the specifications for the optical disc, there is usually an item on jitter of reproduced data. In the inspection for this item, measurement is made of the jitter.

The data reproduced from the optical disc are obtained on reproducing RF signals by an optical pickup and binary coding the reproduced data. The binary-coded data intrinsically has a period equal to an integer number times the period T of reproduced clocks. If the optical disc is an optical disc, data from $3T$ to $11T$ are reproduced. However, the period of the reproduced data undergoes temporal instabilities due to manufacture tolerances or pickup characteristics. For example, data which should be of a time width of $5T$ may be data of $5.3T$ or $4.9T$, without being accurately $5T$ period data. The temporal instabilities, produced on binary-coding RF

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signals of the optical disc, are termed the jitter in the reproduced data.

As the method for inspecting optical disc jitter, an evaluation system, generally termed a 22T system, is used. In this 22T system, the time width from a given edge to an edge existing in a range of $22T \pm 0.5T$ is measured, and a standard deviation on statistically processing plural measured time widths is found. This 22T system is extensively used because it has good correlation with the block error rate.

Specifically, with the 22T system, clocks are started to be counted at an optional edge, and a window is opened between $21.5T$ and $22.5T$. An edge is detected between $21.5T$ and $22.5T$. If there exists an edge in the window, the time width is measured. For example, if an edge t_1 exists in the window, a time width T_1 from an edge t_0 until the edge t_1 is measured.

The next measurement is then started. For example, clocks are started to be counted at the edge t_1 , and a window is opened between $21.5T$ and $22.5T$ as from this edge. If there is no edge within this window, time measurement is not made. If the time width between the edge t_1 and the edge t_2 is $23T$, there is no edge in the window. After closing the window for which no time measurement has been made, clocks are started to be counted as from the next first edge and a window is again opened between $21.5T$ and $22.5T$ to detect an edge.

In the 22T system, the sequence of operations of generating a window, detecting an edge and measuring the time width is repeated to perform time width measurement plural times. The measured data over plural time widths are statistically processed to

find the jitter of reproduced data of the optical disc.

It is noted that, in the above-described 22T system, only data having a period of 22T ($\pm 0.5T$) are used for jitter measurement, such that, if there is no edge during this period of 22T ($\pm 0.5T$), measurement is not made.

Assuming that an edge occurs at a random probability during the time of 22T ($\pm 0.5T$), the probability of the occurrence of an edge is 1/3 for an expected value of the period of the reproduced data equal to 3T. In actuality, there are numerous data having periods longer than 3T. Therefore, the probability of occurrence of an edge during the time of 22T (± 0.5) is 30% or less. That is, only one effective data can be obtained for a period not less than 66T.

Thus, with the conventional 22T system, a lot of time is consumed in measuring data used for statistic processing.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an apparatus for detecting effective data used for statistic processing in a short time for measuring jitter to high precision.

The present invention provides a jitter measurement apparatus for an optical disc including means for reproducing RF signals from an optical disc, binary-coding means for binary-coding the RF signals, storage means for storing binary-coded data from the binary-coding means and means for measuring the jitter of reproduced data of the optical disc based on the data stored in the storage means. The jitter

measurement means measures the time width from an optional edge of the data binary-coded by the binary-coding means to another edge spaced from the optional edge a distance larger than the maximum pit length or the maximum land length of the optical disc, and statistically processes plural such measured time widths to measure the jitter of the reproduced data of the optical disc.

With the present jitter measurement device for the optical disc, the time width as from an optional edge of binary-coded data obtained by the binary-coding means to an edge spaced from the optional edge by a distance longer than the maximum pit length or the maximum land length of the optical disc is measured. This time width is measured plural times by a similar sequence of operations, and the resulting plural time widths are statistically processed to measure the jitter of the reproduced data of the optical disc.

Thus, it is possible to detect a large quantity of effective data usable for statistic processing in a shorter time to effect jitter measurement to high accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 illustrates the contents of measurement processing in case jitter is measured by the conventional 22T system.

Fig.2 is a block diagram showing a jitter measurement device embodying the present invention.

Fig.3 illustrates the contents of measurement processing of the jitter measurement device shown in Fig.2.

Fig.4 illustrates a detecting position of reproduced data of the jitter measurement device shown in Fig.2.

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 a jitter measurement device embodying the present invention.

A jitter measurement device 1, shown in Fig.2, is used for measuring jitter of an optical disc 2 (so-called compact disc) having signals of 3T to 11T recorded thereon.

The jitter measurement device 1 includes an optical pickup 3 for detecting the signals recorded on the optical disc 2, a pre-amplifier 4 for generating reproduced signals (RF signals) from the detected signals of the optical pickup 3, a binary-coding circuit 5 for binary-coding the RF signals, a memory 6 for chronologically storing the binary-coded data and a CPU 7 for measuring the jitter from the data stored in the memory 6.

The jitter measurement method by this jitter measurement device 1 is now explained.

In the memory 6, binary-coded data are stored in the chronological order, with rising and falling edges of each data being stored in meeting with the reproducing time. For example, binary-coded data are assumed to be stored, as shown in Fig.3.

The CPU 7 reads out data stored in the memory 6 and detects a first one (edge in question) of edges present between 19.5T and 31.5T as from an optional edge (starting edge), and the time width between this starting edge and the edge in question is measured. That is, when the time of 19.5T has elapsed as from the starting edge, a window is opened. At 31.5T, this window is closed. Within this window, a temporally initially occurring edge is detected so as to be used as the edge in question. If an edge t_0 shown in Fig.3 is the starting edge, an edge t_3 present at a position of 22T as from this edge t_0 is the edge in question, and measurement is made of the time T_1 between t_0 and t_3 .

Then, for the next edge to the optional edge used for previous measurement, a first edge (edge in question) among the edges present between 19.5T and 31.5T is detected, and measurement is made of the time width between this starting edge and the edge in question. For example, similar measurement is made of t_1 shown in Fig.2. If this edge t_1 is a starting edge, an edge t_4 existing until 24T as from the edge t_1 is the edge in question, and measurement is made of the time T_2 between t_1 and t_4 .

The above-described operation is performed on the totality of edges. For example, time measurement is made of t_2 to t_{11} or even edges lying further to the right of t_{11} in Fig.3.

By measuring the time width for the totality of edges, the number of time-width data for statistic processing can be increased advantageously.

Meanwhile, the starting edges may be solely the rising edges, or solely the

falling edges.

The reason the window is opened and closed when the time of $19.5T$ and the time of 31.5 have elapsed since the starting edge, respectively, is as follows:

In measuring the jitter, it is not desirable to use the information on the edges of the same pit or the same land since the measurement is affected significantly by particular conditions of the manufacturing process. If, for example, the time width between the edges of different lands is used, as shown in Fig.4B, the measurement is affected to a lesser extent by particular conditions of the manufacturing process than if the time width between the starting edge and the terminal edge of the same land as shown in Fig.4A is used. For this reason, the length from the starting edge up to the starting of the window is selected to be longer than the maximum pit length or the maximum land length of the optical disc being measured. Since the maximum pit length is $11T$ (frame sync) in the case of a compact disc, the period as from the starting edge is set to not less than $12T$ in the present embodiment.

In the compact disc, two consecutive $11T$ data are recorded as frame sync. As for other data, the maximum period as from a given pit to the next pit is $(10T + 10T) = 20T$. With this period of $20T$, which is close to $22T$ having a satisfactory correlation with the block error rate, the jitter can be detected to high precision. If, with the time from the starting edge until opening of the window of $20T$, a position of $31T$, obtained on adding $11T$ to this $20T$, is to be the window end position, there is necessarily contained an edge in one window.

By opening and closing the window when the time of $19.5T$ and the time of $31.5T$ have elapsed as from the starting edge, respectively, jitter can be measured for the totality of edges.

Plural jitter values, measured in this manner, are statistically processed to find jitter values of the reproduced data of the optical disc. If, due to constraints proper to the memory or computing units, jitter cannot be measured for the totality of data recorded on the optical disc, jitter can be measured efficiently within limited reproduced data. By setting the window start position to $19.5T$, jitter can be measured efficiently and accurately.

The effective number of data in the conventional 22T system is now compared to that obtained in the jitter measurement device 1.

It is assumed that the probability of occurrence of an edge in a $1T$ period is a .

In the conventional 22T system, since effective data is obtained only when there is an edge during the time a $1T$ window is opened, one effective data is obtained during a period of $(22/a)T$ period. If, for example, $a = 0.33$ (33%), effective data can be detected at a rate of one in $66T$.

On the other hand, since the totality of edges represent effective data in the jitter measurement device 1, an effective data can be detected at a rate of one data for a period equal to a reciprocal of the probability of edge occurrence times T , that is for a period of $(1/a)T$.

It is seen from this that, if the time width is measured using both the rising and

falling edges, 22 times as many effective data as the effective data obtained with the conventional 22T system can be obtained.

WHAT IS CLAIMED IS:

1. A jitter measurement apparatus for an optical disc comprising:

means for reproducing RF signals from an optical disc;

binary-coding means for binary-coding the RF signals;

storage means for storing binary-coded data from said binary-coding means;

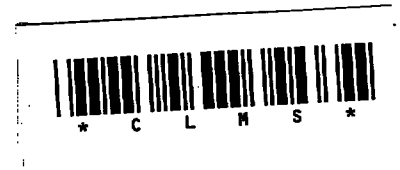
and

means for measuring the jitter of reproduced data of the optical disc based on the data stored in said storage means;

said jitter measurement means measuring the time width from an optional edge of the data binary-coded by said binary-coding means to another edge spaced from said optional edge a distance larger than the maximum pit length or the maximum land length of said optical disc, said jitter measurement means statistically processing plural such measured time widths to measure the jitter of the reproduced data of said optical disc.

2. The jitter measurement apparatus according to claim 1 wherein said optical disc has the clock period of reproduced data equal to T and has data of from $3T$ to $11T$ recorded thereon; and wherein

said jitter measurement means opens a window of a pre-set time width for detecting an edge at a time point separated by not less than $12T$ from the optional edge of the binary-coded data, said jitter measurement means measuring the time width as from said optional edge to an edge existing in said window to measure the jitter of said





optical disc.

3. The jitter measurement apparatus according to claim 2 wherein said jitter measurement means opens, at a time point spaced by not less than $12T$ from an optional edge of binary-coded data, a window not larger than $12T$ for edge detection, said jitter measurement means measuring a time width as from said optional edge to a first edge existing in said window to measure the jitter of reproduced data of said optical disc.