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(54) Abstract Title
Automatic bandwidth control in a waveform equalizer

(57) A method for automatically controlling bandwidth of a waveform equalizer in a DVD (Digital Video Disc) reproducing apparatus. The DVD reproducing apparatus includes an RF amplifier (16) having the waveform equalizer of which bandwidth is determined by a bandwidth control signal, and a digital signal processor (18) for demodulating an EFM signal equalized by the RF amplifier. The DVD apparatus (22) checks an error cycle of an error signal received from the digital signal processor (18) for a predetermined count cycle, while varying the bandwidth control signal step by step, so as to calculate an error rate according to the bandwidth control signal. Thereafter, the DVD apparatus (22) generates to the RF amplifier (16) the bandwidth control signal having a minimum error rate out of the calculated error rates, thereby minimizing an error rate during data reproduction.

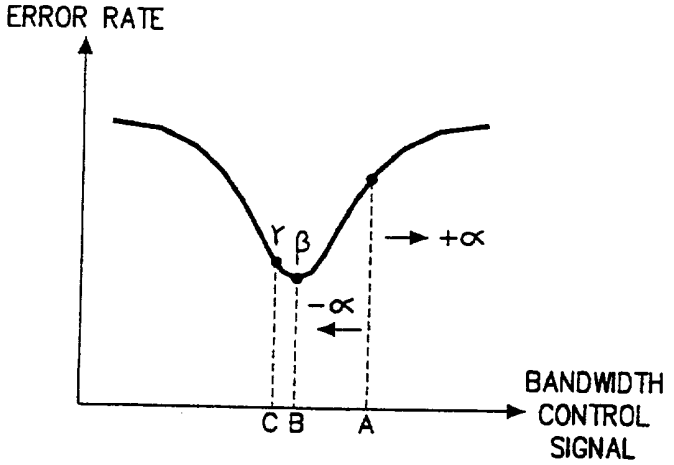

FIG. 2

GB 2 325 079 A

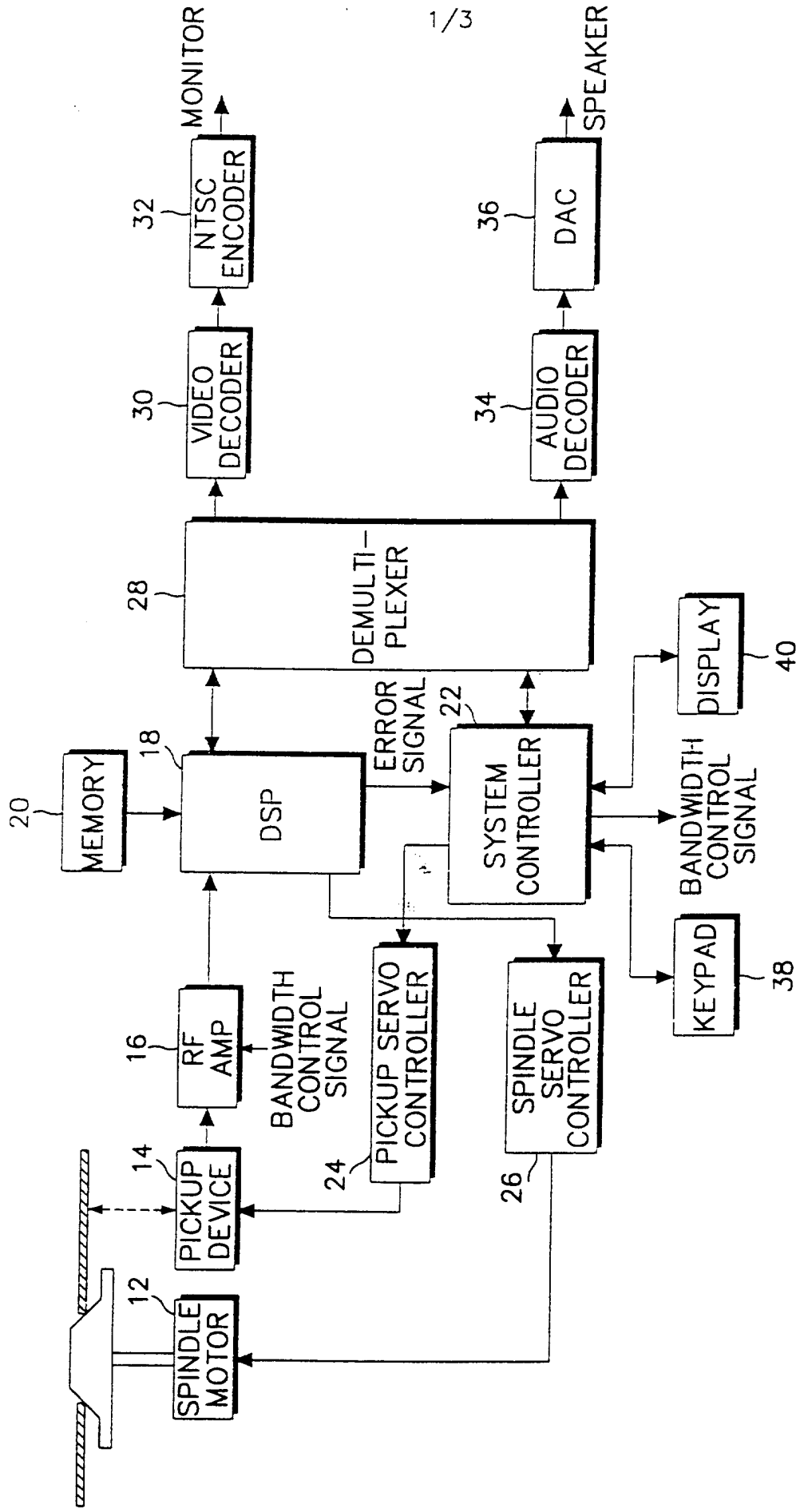
MONITOR
SPEAKER
32
NTSC ENCODER
36
DAC
30
VIDEO DECODER
34
AUDIO DECODER
28
DEMULTI-PLEXER
20
MEMORY
18
DSP
ERROR SIGNAL
22
SYSTEM CONTROLLER
DISPLAY
40
BANDWIDTH CONTROL SIGNAL
16
RF AMP
BANDWIDTH CONTROL SIGNAL
PICKUP SERVO CONTROLLER
24
SPINDLE SERVO CONTROLLER
26
KEYPAD
38
14
PICKUP DEVICE
12
SPINDLE MOTOR

FIG. 1

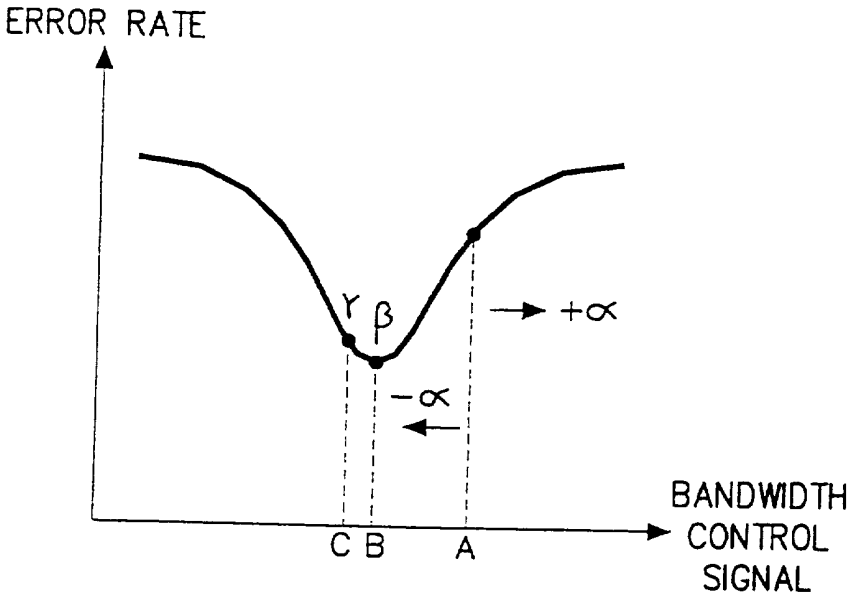

FIG. 2

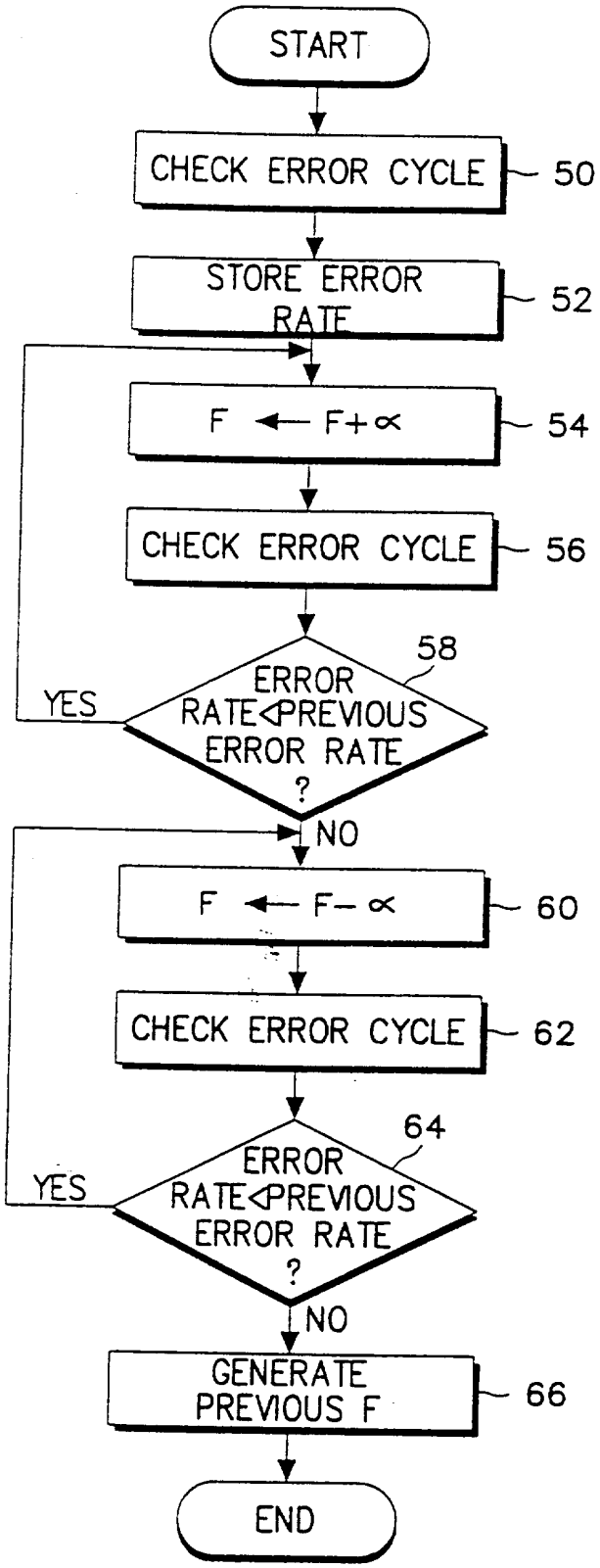
START
CHECK ERROR CYCLE
50
STORE ERROR RATE
52
F ← F+∝
54
CHECK ERROR CYCLE
56
58
ERROR RATE<PREVIOUS ERROR RATE ?
YES
NO
F ← F−∝
60
CHECK ERROR CYCLE
62
64
ERROR RATE<PREVIOUS ERROR RATE ?
YES
NO
GENERATE PREVIOUS F
66
END

FIG. 3

METHOD FOR AUTOMATICALLY CONTROLLING BANDWIDTH OF WAVEFORM EQUALIZER

The present invention relates to a digital video (or versatile) disk reproducing apparatus, and in particular, to a method for automatically controlling bandwidth of a waveform equalizer to minimize a data error rate during pulse detection.

A digital video (or versatile) disc (hereinafter referred to as DVD), a recording medium for the digital moving picture, can record a digital MEPG2 (Moving Picture Experts Group 2) signal of over 2 hours. A general DVD reproducing apparatus for reproducing the audio and video signals recorded on the DVD has a construction as shown in Figure 1.

Referring to Figure 1, a DVD 10 mounted on a driving axle of a spindle motor 12 rotates at a constant speed. A pickup device 14 contained in a deck (not shown) irradiates a laser beam onto the DVD 10 and receives reflected beam from the DVD 10 to read data recorded on the DVD 10. Further, the pickup device 14 controls rotation and loading of the DVD 10 and transfer of a pickup head (not shown). An RF (Radio Frequency) amplifier 16 amplifies the signal picked up by the pickup device 14 and shapes the amplified signal. A digital signal processor (DSP) 18 demodulates (16-8 demodulation) the signal output from the RF amplifier 16, and performs data PLL (Phase Locked Loop) by means of synchronous detection, descrambling, error detection, error correction, and track buffer control function.

Specifically, the DSP 18 includes a 16-8 demodulator (not shown) and a error correction circuit (not shown). The 16-8 demodulator detects synchronization for the input data and 16-8 demodulates the input data to store it into a memory (i.e., track buffer) 20. The error correction circuit reads the data stored in the track buffer 20 to correct errors of the read data and, then stores the error-corrected data back into the track buffer 20. Further, the DSP 18 searches the data stored in the track buffer 20 for ID (identification) data representative of a disc position, to provide the ID data to a system controller 22, and descrambles the remaining data to store it into the track buffer 20. At the request of a video decoder 30, the DSP 18 reads and transfers the descrambled data stored in the track buffer 20 to the video decoder 30.

The system controller 22 controls an overall operation of the DVD reproducing apparatus. A pickup servo controller 24 performs focusing servo, tracking servo and pickup transfer servo, under the control of the system controller 22. A spindle servo controller 26 controls a rotations number of the spindle motor 12, such that a period of the longest or shortest pit of an EFM (Eight-to-Fourteen Modulated) signal read from the DVD 10 should become a prescribed value. A demultiplexer 28 demultiplexes the signal output from the DSP 18, to transfer a video signal to an MPEG2 video decoder 30 and an audio signal to an AC3/MPEG audio decoder 34, respectively. The video and audio output signals from the video decoder 30 and the audio decoder 34 are transferred to a monitor and a speaker via an NTSC encoder 32 and a digital-to-analog converter (DAC) 36, respectively. A user interface means, such as a keypad 38 having a plurality of keys, allows the user to input data or commands. A display

40 displays thereon various state information concerning reproduction of the DVD 10.

The RF amplifier 16 of such a DVD reproducing apparatus generally includes an adder (not shown) and a waveform equalizer (not shown). In operation, since the signal picked up by the pickup device 14 is divided into four signals for the focusing servo and grouped into two groups, those signals undergo an I-V (current-to-voltage) conversion and are then converted into a signal of a single group. The EFM signal amplified and shaped at the adder is a 3-14T pulse train, so that the reproduced signal is liable to an error due to interference between adjacent waveforms. Accordingly, there has long been a demand for a device which can reduce bandwidth of the waveform equalizer as narrow as possible in order to minimize the interference and, as a result, reduce the error rate during pulse detection. Conventionally, a jitter meter was used in order to reduce the bandwidth of the waveform equalizer. That is, the conventional device measured the EFM signal equalized at the waveform equalizer by using the jitter meter, to determine the bandwidth of the waveform equalizer. Accordingly, the bandwidth of the waveform equalizer is determined passively, so that the bandwidth is inaccurately determined, thereby increasing the data error rate undesirably.

It is therefore an aim of at least preferred embodiments of the present invention to provide a method for automatically controlling bandwidth of a waveform equalizer to minimize a data error rate in a DVD reproducing apparatus.

According to a first aspect of the present invention, there is provided a method for automatically controlling bandwidth of a waveform equalizer in a DVD reproducing apparatus. The DVD reproducing apparatus includes an RF amplifier having the waveform equalizer of which bandwidth is determined by a bandwidth control signal, and a digital signal processor for demodulating an EFM signal equalized by the RF amplifier. The DVD apparatus checks an error cycle of an error signal received from the digital signal processor for a predetermined count cycle, while varying the bandwidth control signal step by step, so as to calculate an error rate according to the bandwidth control signal. Thereafter, the DVD apparatus generates to the RF amplifier the bandwidth control signal having a minimum error rate out of the calculated error rates, thereby minimizing an error rate during data reproduction.

According to a second aspect of the present invention there is provided a method for automatically controlling bandwidth, said method for use in an optical disc reproducing apparatus having a waveform equalizer of which bandwidth is determined by a bandwidth control signal, and a digital signal processor producing an error signal, said method comprising the steps of:

calculating an error rate by counting an error cycle of the error signal for a predetermined count cycle, at a first bandwidth;

changing said bandwidth and repeating said checking step;

comparing said calculated error rates to determine the bandwidth control signal resulting in the minimum

error rate out of the calculated error rates, thereby minimising said error rate during data reproduction.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is block diagram of a general DVD reproducing apparatus;

Figure 2 is an error rate characteristic curve with respect to a bandwidth control signal according to a preferred embodiment of the present invention; and

Figure 3 is a flow chart for searching for a bandwidth control signal having a minimum error rate according to a preferred embodiment of the present invention.

A preferred embodiment of the present invention will be described in detail hereinbelow with reference to the accompanying drawings. For comprehensive understanding of the present invention, the present invention will be illustratively described, confined to the specific embodiment. However, it should be noted that the present invention can be implemented by anyone skilled in the art with the description, not the details. In the following description, well-known functions or constructions which may obscure the present invention in unnecessary detail are not described in detail.

Figure 2 shows an error rate characteristic curve with respect to a bandwidth control signal according to a preferred embodiment of the present invention, and Figure

3 shows a flow chart of the system controller 22, for searching for a bandwidth control signal having a minimum error rate according to a preferred embodiment of the present invention. With reference to Figure 1, upon receiving an error signal from the DSP 18, the system controller 22 counts an error cycle E_r of the error signal for a predetermined count cycle T to calculate an error rate (E_r/T). The system controller 22 generates to the RF amplifier 16 a bandwidth control signal for minimizing the error rate. In Figure 2, the X-axis represents the bandwidth control signal F generated from the system controller 22, and the Y-axis represents the error rate value which varies depending on the bandwidth control signal F. The error signal mentioned above refers to a signal generated after the error correction, and the error cycle E_r represents a time for sustaining the active state.

Now, referring to Figure 3, description will be made on how the system controller 22 determines the bandwidth control signal having the minimum error rate according to the preferred embodiment of the present invention.

First, at step 50, the system controller 22 checks the error cycle E_r, at a certain point, for example, at a point A of the bandwidth control signal F. The system controller 22 checks the error cycle E_r for a predetermined count cycle T, to calculate the corresponding error rate. The calculated error rate is stored into an internal memory as an initial error rate, at step 52. Thereafter, the system controller 22 increases the bandwidth control signal F by α, at step 54 and checks again the error cycle E_r to calculate the corresponding error rate, at step 56. After calculating the error rate, the system controller 22 compares the current error rate calculated at the step 56 with the previous error rate stored into the internal

memory. As the result, if the current error rate is lower than the previous error rate, the system controller 22 returns to the step 54 to increase again the bandwidth control signal F by α and calculate the corresponding error rate. However, as shown in Figure 2, if the current error rate is higher than the previous error rate, the system controller 22 proceeds to step 60 to decrease the bandwidth control signal F by α. After decreasing the bandwidth control signal F, the system controller 22 checks the error cycle and calculates the error rate according thereto, at step 62. Thereafter, the system controller 22 compares again the current error rate calculated at the step 62 with the previous error rate calculated at the step 56. If the current error rate is lower than the previous error rate, the system controller 22 returns to the step 60 to decrease again the bandwidth control signal F by α and calculate the corresponding error rate. However, as shown in Figure 2, if the current error rate γ is higher than the previous error rate β, the system controller 22 decides that the previous error rate β calculated at the point B is the minimum error rate. Thus, at step 66, the system controller 22 generates the bandwidth control signal F of the previous point B to the RF amplifier 16. In this manner, the system controller 22 can automatically control the bandwidth of the waveform equalizer. As a result, it is possible to minimize the interference between adjacent waveforms generated from the DVD 10, thereby minimizing the error rate during pulse detection.

As described above, the preferred method measures the error rate while varying the bandwidth of the waveform equalizer, to determine the bandwidth of the waveform equalizer at the point having the minimum error rate.

Therefore, it is possible to minimize the data error rate due to jitter.

Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various other changes and modifications may be affected therein by one skilled in the art without departing from the scope of the invention.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any

novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A method for automatically controlling bandwidth of a waveform equalizer in an optical disc reproducing apparatus including an RF (Radio Frequency) amplifier for amplifying a signal read from said optical disc by an optical pickup, said RF amplifier having said waveform equalizer of which bandwidth is determined by a bandwidth control signal, said optical disc reproducing apparatus further including a digital signal processor for demodulating an EFM (Eight-Fourteen Modulated) signal equalized by said RF amplifier and performing data PLL (Phase Locked Loop) by means of synchronous detection, descrambling, error detection, error correction and track buffering function, said method comprising the steps of:

checking an error cycle of an error signal received from said digital signal processor for a predetermined count cycle, while varying the bandwidth control signal step by step, so as to calculate an error rate according to the bandwidth control signal; and

generating to said RF amplifier the bandwidth control signal having a minimum error rate out of the calculated error rates, thereby minimizing an error rate during data reproduction.

2. A method for automatically controlling bandwidth of a waveform equalizer in an optical disc reproducing apparatus including an RF amplifier for amplifying a signal read from said optical disc by an optical pickup, said RF amplifier having said waveform equalizer of which bandwidth is determined by a bandwidth control signal, said optical disc reproducing apparatus further including a digital signal processor for demodulating an EFM signal

equalized by said RF amplifier and performing data PLL by means of synchronous detection, descrambling, error detection, error correction and track buffering function, said method comprising the steps of:

checking an error cycle of an error signal received from said digital signal processor for a predetermined count cycle at a bandwidth;

changing said bandwidth, such that an error rate at the current bandwidth is lower than an error rate at the previous bandwidth, and checking the error cycle of the error signal received from said digital signal processor for the predetermined count cycle at the respective bandwidths so as to calculate the corresponding error rates; and

if the error rate calculated at the current bandwidth is higher than the error rate calculated at the previous bandwidth, generating to said RF amplifier the bandwidth control signal for the previous bandwidth, thereby minimizing the error rate during data reproduction.

3. A method for automatically controlling bandwidth, said method for use in an optical disc reproducing apparatus having a waveform equalizer of which bandwidth is determined by a bandwidth control signal, and a digital signal processor producing an error signal, said method comprising the steps of:

calculating an error rate by counting an error cycle of the error signal for a predetermined count cycle, at a first bandwidth;

changing said bandwidth and repeating said checking step;

comparing said calculated error rates to determine the bandwidth control signal resulting in the minimum error rate out of the calculated error rates, thereby minimising said error rate during data reproduction.

4. A method according to claim 3, further comprising any one or more of the features disclosed in the accompanying specification, claims, abstract and/or drawings, in any combination.

5. A method substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

The Patent Office

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Application No: [Application No.] **Examiner:** <Name>
Claims searched: 1 to 5 **Date of search:** 8 July 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G5R (RB32, RB33)

Int Cl (Ed.6): G11B 7/00, 20/10, 20/18

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5610776	(OH)	1, 2, 3
X	US 5533031	(DOUNN et al)	1, 2, 3

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.