PREFORMATTED DIAGNOSTIC INFORMATION RECORDING DISK

A preformatted diagnostic information recording disk (1) for use in an optical disk storage and retrieval device for allowing the disks upon which user data is recorded to be used to provide diagnostic information to the device for the automatic performance of diagnostic routines in order to verify proper device operation. The preformatted disk has a plurality of information tracks (2a, 2b, 2c,...) each having a specific data pattern designed to test for a specific device function. In the preferred embodiment parameters tested include high frequency data recording (track 2a), low frequency data recording (track 2b), rapid variation data recording (tracks 2d, 2e, 2f), DC offset compensation (track 2g), clocking/data recording signal isolation (tracks 2h - 2i), galvo centering verification (track 2j), rapid access functioning, read spot alignment (tracks 2k - 2l), and read/write functioning (area 3).
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PREFORMATTED DIAGNOSTIC INFORMATION RECORDING DISK

BACKGROUND OF THE INVENTION

This invention relates to the field of testing and diagnosis of machine performance parameters, and more particularly to the in-device diagnosis and testing of information storage and retrieval devices.

As information storage and retrieval devices have grown more powerful, they have also grown more complex. As the devices have grown in complexity, the need for verification of proper device performance has increased along with a need for more sophisticated diagnostic testing procedures when the machine has malfunctioned. Proper device operation has become even more critical as end users of devices become more and more dependent upon their information storage devices. Should the device become inoperative, timely repair is a necessity. This need has caused intensive research in the area of improving the testing and diagnostic procedures used to verify machine performance.

In magnetic tape and disk drives, diagnostic testing routines are well known to those known in the art. However, with magnetic tape and disk drives, diagnostic routines have ordinarily required either the mounting of a special diagnostic disk, or moving to a specified portion of the disk and attempting to write and read test data in order to verify machine performance. This has lead to a number of problems. For example, with a magnetic disk drive, the fact that test data must be written and read makes it difficult to determine whether the malfunction is in the write function or the read function. Also, when it is necessary to mount a separate diagnostic disk, should centering of the disk be a problem, the mounting and demounting may cause difficulty in finding this
problem. Finally, significant time is lost in attempting to trace a problem to a specific reading or writing problem. What is needed therefore is a means for immediately being able to segregate the class of malfunction or performance verification problem, as well as addressing the significant problems related to disk miscentering.

SUMMARY OF THE INVENTION

In the preferred embodiment of the disclosed invention, a preformatted diagnostic information recording disk for use in a device having removable disks is comprised of: an optically smooth and light reflective substrate, (or alternatively, a separate planarizing and light reflective layers overlaying the substrate), and an active layer of light absorbing material deposited over the reflecting surface. In the preferred embodiment, data for diagnostic information use is recorded in the active layer of the disk by irradiation by focus laser beam, causing a mark to be formed in the active layer (this mark or absence of a mark representing data points). In the preferred embodiment, the disk is preformatted by placing the disk in a servo writing machine which precisely writes concentric information tracks on the disk surface. A plurality of diagnostic tracks are written, each for the specified purpose. By preformatting the disk with precisely written tracks, the problem of segregating a read problem from a write problem is eliminated.

In the preferred embodiment, the platter disk is divided by the servo/clocking tracks into 716 bands, of which 713 are available for user data. The bands are addressed consecutively in ascending sequence has been 0 through 715 from the outer band toward the inner. The bands are separated by special servo coarse seek tracks which also are designed to provide a clocking signal. Within a
band, tracks are numbered consecutively in ascending sequence from the outside of the band to the inside. In the preferred embodiment there are two special purpose bands. The first band is the diagnostic band used for providing diagnostic information for the device diagnostic routine. The second band is the index band used for assisting in the device random access rapid seek function. In the preferred embodiment there are 48 user tracks, per user band. Each track is divided into segments called blocks. User data is encoded and written to specified blocks when stored on the platter.

In the presently contemplated embodiment, a track is written to test for proper reading of high transition rate user data, low transition rate user data, for worse case DC offset, for the worse case user data recorded with rapid variations in data transition frequency, for interference of user data with the clocking sequence for the disk, for testing the device rapid band search technique; for testing the proper electrical and mechanical centering of the servo galvo mirrors, and to verify the proper alignment of the read/write focus and tracking spots. In addition to the specific tracks encoded in the diagnostic band, a significant amount of space is left unwritten to allow for the writing of test data in order to verify a proper write function for the device. The preformatted disk is therefor a valuable tool in testing for all levels of diagnostic routines, including host, control unit and device performance.

To achieve these various diagnostic testing modes, a plurality of different byte patterns are laid down on each of the individual tracks. In the preferred embodiment, the disk is also preformatted with a plurality of clocking/coarse seek bands. The clocking bands are used for proper synchronization of data reading and writing. The coarse seek bands are used to aid the random access coarse and
fine seek function of the optical storage and retrieval device, for
which use of this disk is contemplated. To aid in the random access
mode, data is recorded on a plurality of tracks between the coarse
seek/servo clocking tracks, defining a band. In the preferred
embodiment, it is contemplated that all of the diagnostic tracks
will be placed in the outermost band of the disk hereinafter
referred to as the diagnostic band. In addition to the preformatted
tracks, a significant area of the diagnostic band remains unwritten
to specifically allow test writing on the unwritten portions in
order to verify device writing capabilities.

Thus, the device may be tested both for its reading performance
based upon reading precisely written preformatted information, and
well as being able to write on unwritten disk surface in order to
verify the writing function. Also, it is contemplated that this
disk will be used in a machine having removable media, therefore it
is contemplated that each user disk would have preformatted thereon
the diagnostic information tracks. Thus, problems related to disk
miscentering can be tested because the disk need not be replaced
prior to initiating the diagnostic routine.

Upon device spin up, the device controller automatically
initiates a diagnostic sequence. During the sequence, the program
will automatically call for the machine to first go to the
preformatted tracks and test the various reading functions of the
machine including the high and low data rate sensing functions, the
precise alignment of the read/write focus and tracking spots, the
proper centering of the tracking galvo, and the DC offset circuits.
Additional higher order diagnostic routines can then conduct a
series of rapid band searches in order to verify the rapid band
search function of the device and, intensive read testing and
write/read testing to verify other higher order functions.
Also in the preferred embodiment, in order to test the random access and rapid band search function of the optical storage device, it is contemplated that the disk shall also have an index band which will have recorded thereon the location of the specific diagnostic tracks, which will also allows verification of the device search algorithm.

The diagnostic tracks are also used to check machine performance should malfunction occur. Upon sequencing through the diagnostic routine, and interpreting the resulting read back information, experience will indicate the type of failure mode which is being encountered.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a top schematic representation of a recording disk, showing the coarse seek/servo bands.

FIGURE 2 is an exploded view of the indicated area of FIGURE 3, showing the coarse seek tracks bounding the diagnostic band and representations of the diagnostic tracks.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIGURES 1 and 2, the disk 1 has a plurality of coarse seek/clocking tracks 2 servo written thereon at the manufacturing facility. The area between the servo/clocking tracks defines bands 3, in which information tracks 4 are to be written. At the manufacturing facility, the preformatted diagnostic tracks 4a-4p are also written, with remaining areas for writing user information.
FIGURE 2 is an exploded view of area A-A of FIGURE 1. FIGURE 2 shows the servo written preformatted tracks including, coarse seek tracks 2a and 2b, and a plurality of diagnostic tracks 4a-4p, each of which will be described below, along with unwritten surface for the writing of test data. Each of the diagnostic tracks are specifically recorded to provide a specific diagnostic testing mode, in order to verify that a particular circuit or operating mode is functioning properly. Together this area defines the diagnostic band 5. The coarse seek tracks 2 are written at a 50% duty cycle and are used for timing purposes as well as aiding in the random access function of the device.

Looking more particularly at FIGURE 2, a first diagnostic track 4a is servo written at a high frequency (in the preferred embodiment, a 8MHz frequency) 50% duty cycle using a 92H, 49H, 24H, 32 bit repeating cycle in order to stress the PLL read circuit in a worse case user recording mode. This is to provide a read data pattern which shows the high extreme of data recording, in order to verify that the read circuit can respond an accurately read data at this rate.

Track 4b is a 50% duty cycle low frequency 32 bit group of code repeating 35H. This low frequency duty cycle is testing the read circuits response to low in data at the 3MHz frequency range. Together track 4a and 4b fully stress the read circuit at the constant high and low extremes of data reading.

Track 4c in the preferred embodiment, is a 2-6 duty cycle 32 byte group of data points recorded in order to introduce a DC offset signal into the phase lock loop circuit. For example, if a square wave of +2 to -2 volts at a 50% duty cycle is fed into a circuit, the average voltage is 0. However, with a 2-6 duty cycle, the average is off zero, and can send an offset signal into the read
circuit. By coding track 4c with this DC offset data pattern, the diagnostic routine can verify that the device electronics can compensate for this offset signal.

In the preferred embodiment, tracks 4d, 4e and 4f are each written to have rapid variations in the modulation of the recorded data in order to test the phase lock loop circuits for rapid changes and user data recording. In the preferred embodiment, track 4d is recorded in code corresponding to 16 bytes of 33H, 16 bytes repeating of 32H, 49H, 24H. Track 4e is recorded in 32 bytes of repeating 33H, 33H, 30H, 8AH, A8H, A2H. Track 4f is recorded in 32 bytes of repeating code 49H, 2. Together tracks 4d-f provide a full range of rapid data frequency variations in order to fully test the systems response to rapid variations in customer data.

As shown in FIG. 2, in the preferred embodiment of the disclosed invention, the clocking tracks 2 function at 50% duty cycle and are also used for coarse seeking operations. A problem can exist with interference between customer data recorded at this frequency causing a malfunction in the coarse seek operation. Correspondingly, tracks 4h-4l are encoded with binary information which corresponds to the coarse seek pattern in order to verify that the system can isolate coarse seek track information from customer information recorded at the same frequency.

In the optical storage and retrieval device contemplated to use the disclosed invention, a multiple spot array is used for reading, writing, tracking and focussing. Because of variations in laser design, and laser aging, the precise spacing of the read, focus and tracking beams may vary. Thus, it is necessary to verify that precise alignment is attained as well as verifying proper alignment should a malfunction occur. Accordingly, two precisely spaced
tracks 4m and 4n are servo written in order to provide a means for verifying the proper track pitch is maintained in the system.

In the preferred embodiment, two tracks 4m and 4n are precisely spaced with respect to each other. During the diagnostic routine, the read, focus and tracking beams are placed upon tracks 4m and 4n and the feedback signal is analyzed for proper spot spacing. If proper alignment is attained, a proper signal will be generated verifying the machines proper pitch, however, should the signals be incorrect, a malfunction signal can be generated by the diagnostic routine indicating misalignment of the read beams.

A centering track 4p, precisely spaced between coarse seek tracks 2a and 2b, can be used to properly verify the device tracking system. By focussing on this precisely centered track, and by sensing the mechanical electrical alignment of the servo system, proper physical alignment reading and writing functions can be diagnosed.
CLAIMS

What is claimed is:

1. A preformatted diagnostic information recording disk for verification of performance parameters and malfunction diagnosis in an information storage and retrieval device, said recording disk comprised of a recording disk deposited upon the disk substrate, said recording structure having a plurality of preformatted precisely aligned and positioned concentric data tracks, such that upon loading of the disk into the device, the device diagnostic routine can cause the preformatted tracks to be read and interpreted to verify device performance.

2. A preformatted diagnostic information recording disk as recited in Claim 1, wherein the preformatted data tracks are comprised of permanently recorded data tracks.

3. A preformatted diagnostic information recording disk as recited in Claim 2 wherein the information recording disk is comprised of an optical recording disk for use in an optical disk storage and retrieval device.

4. A preformatted diagnostic information recording disk as recited in Claim 3 wherein in a device having a set of focused spots for reading, tracking and focusing, the preformatted tracks are comprised of a pair of precisely spaced tracks for verification of the proper spacing of the read track and focusing spots.
5. A preformatted diagnostic information recording disk as recited in Claim 4 wherein one preformatted track is comprised of a high-transition rate data pattern for verifying device high-frequency data sensing and processing.

6. A preformatted diagnostic information recording disk as recited in Claim 5 wherein the high frequency data pattern is a repeating, 50% duty cycle, 32 byte coded 92H, 49H, 24H data pattern, for testing an 8 MHz data transition rate.

7. A preformatted diagnostic information recording disk as recited in Claim 6 wherein one preformatted track comprises a low-transition rate data pattern for verifying device low-frequency data sensing and processing.

8. A preformatted diagnostic information recording disk as recited in Claim 7 wherein the low frequency data pattern is comprised of a 50% duty cycle having a 32 byte repeating 33H data pattern for testing 3 MHz data transition rate.

9. A preformatted diagnostic information recording disk as recited in Claim 8 wherein one preformatted track is comprised of a data pattern for introducing a DC offset signal into the device read circuitry to verify proper operation of device DC offset compensating circuits.

10. A preformatted diagnostic information recording disk as recited in Claim 9 wherein the DC offset pattern is comprised of a 2-6 duty cycle having a 31 byte repeating 83H, (18H, C6H, 31H, 8CH, 63H) data pattern.
11. A preformatted diagnostic information recording disk as recited in Claim 10 wherein one preformatted track is comprised of a rapid data fluctuation data pattern for verifying operation of the phase lock loop of the read synchronization circuit.

12. A preformatted diagnostic information recording disk as recited in Claim 11 wherein the rapid data fluctuation pattern is comprised of a repeating 16 byte 33H pattern, a 16 byte pattern of 92H, 49H, 24H.

13. A preformatted diagnostic information recording disk as recited in Claim 11 wherein the rapid fluctuation rate data pattern is comprised of a repeating 32 byte code having 33H, 33H, 30H, 8AH, AAH, A2H.

14. A preformatted diagnostic information recording disk as recited in Claim 11 wherein the rapid rate fluctuation pattern is comprised of a 32 byte repeating code having 49H, 24H, 69H, 2.

15. A preformatted diagnostic information recording disk as recited in Claim 11 wherein said disk further comprises a user information. A preformatted diagnostic information recording disk as recited in Claim 11 wherein the rapid fluctuation rate data pattern is comprised of a repeating 32 byte code having 33H, 33H, 30H, 8AH, AAH, A2H.

14. A preformatted diagnostic information recording disk as recited in Claim 11 wherein the rapid rate fluctuation pattern is comprised of a 32 byte repeating code having 49H, 24H, 69H, 2.
15. A preformatted diagnostic information recording disk as recited in Claim 11 wherein said disk further comprises a user information recording structure, for recording of user mass storage data.

16. A preformatted diagnostic information recording disk as recited in Claim 15, wherein in a device having a plurality of clocking tracks, said clocking tracks equally spaced concentrically on said disk surface, and having space between thereto, further comprising an area for the recording of user mass storage data such that the space between clocking tracks defines an information recording band.

17. A preformatted diagnostic information recording disk as recited in Claim 16 wherein in a device having preformatted clocking tracks, one preformatted diagnostic track is comprised of a data pattern for verifying device read circuit insensitivity to information recorded at device clocking frequency.

18. A preformatted diagnostic information recording disk as recited in Claim 17 in a device having a fine tracking system, said system having -galvos for fine tracking adjustment, further comprising a preformatted centering track for verifying the mechanical and electrical centering of said galvos in the servo system, said center track spaced in the center location of the diagnostic band.
19. A preformatted diagnostic information recording disk as recited in Claim 18 further having a means for rapid band search, and having an index band, said index band have recorded therein, the location of diagnostic tracks in the diagnostic band, a means for verifying proper rapid band search function, said means comprised of a data pattern recorded on block in each diagnostic track, said pattern providing information for verification of proper rapid band search operation.

20. A preformatted diagnostic information recording disk as recited in Claim 19 wherein the plurality of preformatted diagnostic tracks are grouped together in a single diagnostic band.
**INTERNATIONAL SEARCH REPORT**

International Application No PCT/US84/01513

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *

According to International Patent Classification (IPC) or to both National Classification and IPC

U.S. Cl.: 369/54
INT. Cl.: 3 G11B 7/00

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Minimum Documentation Searched

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT†

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<td>US, A, 4,428,075 (Hazel et al) 24 January 1984</td>
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* Special categories of cited documents: 14

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"A" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 1

24 October 1984

Date of Mailing of this International Search Report 1

20 November 1984

International Searching Authority 1

Signature of Authorized Officer 25

ISA/US

Form PCT/ISA/210 (second sheet) (October 1981)