SUMMARY OF THE INVENTION

In addition, the user can choose to operate the drive in single mode at full capacity, redundant mode at reduced capacity, or in a combination mode with some single and some redundant modes within the same drive. This definition is determined when the user prepares the drive during the formatting process and can be changed by reformatting the drive to another configuration.

According to one aspect of the present invention there is provided a data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media, said transducing means accessing data on one and only one of said parallel tracks at a time;

means for recording data on said device a multiplicity of times at out of phase locations,

said means for recording data at each of the multiplicity of locations recording said data at a density that exceeds the density at which the data can be read at an acceptable level of errors,

whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the multiplicity of data locations is within said acceptable level of errors;

means for accessing data recorded on said device a multiplicity of times by selectively accessing one of said multiplicity of out of phase locations,

said one of said multiplicity of out of phase locations being selected based on latency time required to access data stored at each of said multiplicity of out of phase locations; and

means for effecting either single recording or multiple recording on a given track on said media.

According to another aspect of the present invention there is provided a data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media; means for recording data on tracks of said media a plurality of times at substantially uniform angular displacements; and

means for effecting either single recording or multiple recording on a given track on said media.

According to still another aspect of the present invention there is provided a control apparatus for a data recording device wherein data is recorded in parallel tracks on a recording media that repetitively pass a transducing location, said data recording device having a single data transducer capable of accessing data on one and only one of said parallel tracks at a time, said control apparatus comprising:

means for positioning said data transducer to write data on and read data from said media;

means for recording data on said media a multiplicity of times at out of phaselocations,

said means for recording data at each of the multiplicity of locations recording said data at a density that exceeds the density at which the data can be read at an acceptable level of errors,

whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the multiplicity of data locations is within said acceptable level of errors;

means for accessing data recorded on said device a multiplicity of times by selectively accessing one of said multiplicity of out of phase locations, said one of said multiplicity of out of phase locations being selected based on latency time required to access data stored at each of said multiplicity of out of phase locations: and

means for effecting either single recording or multiple recording on a given track on said media.

According to still another aspect of the present invention there is provided a control apparatus for a data recording device wherein data is recorded in parallel tracks on a recording media that repetitively pass a transducing location, said control apparatus comprising:

means for positioning a data transducer to write data on and read data from said media;

means for recording data on tracks of said media a plurality of times at substantially uniform angular displacements; and

means for effecting either single recording or multiple recording on a given track on said media.

According to still another aspect of the present invention there is provided a data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media; and

means for recording data on at least some of the tracks a first time using a first encoding method and a second time using a second encoding method, said second encoding method being different from said first encoding method.

According to still another aspect of the present invention there is provided a control apparatus for a data recording device wherein data is recorded in parallel tracks on a record media that repetitively pass a transducing location, said control apparatus comprising

means for positioning a data transducer to write data on and read data from said media; and

means for recording a data on at least some of the tracks a first time using a first encoding method and a second time using a second encoding method, said second encoding method being different from said first encoding method.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic showing of a disk drive media surface wherein a track has been redundantly recorded 180 degrees out of phase. Fig. 2 shows a single sector of a data track. Fig. 3 is a showing similar to Fig. 1 wherein a mixed format of redundant and normal recording is used. Fig. 4 is a block diagram of a disk drive control system including the redundant recording technique of the present invention.

DETAILED DESCRIPTION

The disk drive industry trend is for specific user applications to require ever increasing performance, which is satisfied by increasing spindle rotational velocities and reducing access times. The need for improved access speed and data rate performance places demands on specific form factor constraints such as the spindle and actuator mass, power consumption and bearing life. At a given form factor, the cost of improving these performance numbers by a significant percentage is substantial. This invention is directed to solving the problem of reducing latency in disk storage devices without increasing the rotational speed of the device and with minimal impact on the storage capacity and error rate performance.

CLAIMS

1. A data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media, said transducing means accessing data on one and only one of said parallel tracks at a time;

means for recording data on said device a multiplicity of times at out of phase locations, said means for recording data at each of the multiplicity of locations recording said data at a density that exceeds the density at which the data can be read at an acceptable level of errors, whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the multiplicity of data locations is within said acceptable level of errors;

means for accessing data recorded on said device a multiplicity of times by selectively accessing one of said multiplicity of out of phase locations.

said one of said multiplicity of out of phase locations being selected based on latency time required to access data stored at each of said multiplicity of out of phase locations; and means for effecting either single recording or multiple recording on a given track on said media.

2. The data recording device of claim 1 wherein said recording device is a magnetic disk drive and data is duplicated on the same track on said media.

3. The data recording device of claim 2 wherein data duplicated on the same track 180 degrees out of phase from the initial recording location.

4. The data recording device of claim 3 wherein the duplicated data is initially written at a first location using a first encoding system and is duplicated by being written using a second encoding system, said second encoding system being different from said first encoding system.

5. The data recording device of claim 4 wherein said first and second encoding systems are different forms of run length limited codes.

6. The data recording device of claim 1 further comprising control means, said control means being operable to format said recording device to designate a first portion of said recording media for normal data recording and a second portion of said recording media for redundant recording of data at a multiplicity of out of phase locations.

7. The data recording device of claim 6 wherein a user command is operable to define the size of said first and second portions of said recording media effected by a format or reformat operation.

8. A data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media;

means for recording data on tracks of said media a plurality of times at substantially uniform angular displacements; and

means for effecting either single recording or multiple recording on a given track on said media.

9. The data recording device of claim 8 wherein said media is a rigid disk magnetic media and said means for recording data includes means for twice recording data on a single track at first and second track locations 180 degrees out of phase from one another.

10. The data recording device of claim 9 wherein said means for recording data causes data to be recorded at said first track location using a first run length limited code and at said second track location using a second run length limited code.

11. The data recording device of claim 10 wherein said data written at said first and second track locations is recorded at a linear density that exceeds the density at which data can be read with an acceptable level of errors, whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the locations is within the acceptable level of errors.

12. The data recording device of claim 8 further comprising a control means including a format function, said format function operable to designate a first portion of said recording media for normal recording and a second portion of said recording media for redundant recording wherein data is recorded at a multiplicity of out of phase locations.

13. The data recording device of claim 12 wherein said control means is responsive to a user command to designate the size of said first and second portions effected by a format operation.

14. A control apparatus for a data recording device wherein data is recorded in parallel tracks on a recording media that repetitively pass a transducing location, said data recording device having a single data transducer capable of accessing data on one and only one of said parallel tracks at a time, said control apparatus comprising:

means for positioning said data transducer to write data on and read data from said media;

means for recording data on said media a multiplicity of times at out of phaselocations, said means for recording data at each of the multiplicity of locations recording said data at a density that exceeds the density at which the data can be read at an acceptable level of errors.

whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the multiplicity of data locations is within said acceptable level of errors;

means for accessing data recorded on said device a multiplicity of times by selectively accessing one of said multiplicity of out of phase locations, said one of said multiplicity of out of phase locations being selected based on latency time required to access data stored at each of said multiplicity of out of phase locations: and

means for effecting either single recording or multiple recording on a given track on said media.

15. The control apparatus for a data recording device of claim 14 wherein said data recording device is a magnetic disk drive, and said means for recording data a multiplicity of times records data a multiplicity of times on the same track on said media.

16. The control apparatus for a data recording device of claim 15 wherein said means for recording data a multiplicity of times duplicates data on the same track 180 degrees out of phase from the initial recording location.

17. The control apparatus for a data recording device of claim 14 wherein said means for recording data a multiplicity of times records data at a first location using a first encoding system and records said data at a second location using a second encoding system, said second encoding system being different from said first encoding system.

18. The control apparatus for a data recording device of claim 14 further comprising control means, said control means being operable to format said recording device to designate a first portion of said recording media for normal data recording and a second portion of said recording media for redundant recording of data at a multiplicity of out of phase locations.

19. A control apparatus for a data recording device wherein data is recorded in parallel tracks on a recording media that repetitively pass a transducing location, said control apparatus comprising:

means for positioning a data transducer to write data on and read data from said media;

means for recording data on tracks of said media a plurality of times at substantially uniform angular displacements; and

means for effecting either single recording or multiple recording on a given track on said media.

20. The control apparatus for a data recording device of claim 19 wherein said media is a rigid disk magnetic media and said means for recording data includes means for twice recording data on a single track at first and second track locations 180 degrees out of phase from one another.

21. The control apparatus for a data recording device of claim 20 wherein said

means for recording data causes data to be recorded at said first track location using a first encoding method and at said second track location using a second encoding method, said second encoding method being different from said first encoding method.

22. The control apparatus for a data recording device of claim 20 wherein said data written at said first and second track locations is recorded at a linear density that exceeds the density at which data can be read with an acceptable level of errors, whereby if an error occurs, the data can be read at the alternate recording location and the error rate after reading at each of the locations is within the acceptable level of errors.

23. The control apparatus for a data recording device of claim 19 further comprising formatting control means including a format function, said format function operable to designate a first portion of said recording media for normal recording and a second portion of said

recording media for redundant recording wherein data is recorded at a multiplicity of out of phase locations.

24. A data recording device wherein data is recorded in parallel tracks that repetitively pass a transducing location comprising;

a recording media;

transducing means positionable to write data on and read data from said media; and

means for recording data on at least some of the tracks a first time using a first encoding method and a second time using a second encoding method, said second encoding method being different from said first encoding method.

25. A control apparatus for a data recording device wherein data is recorded in parallel tracks on a record media that repetitively pass a transducing location, said control apparatus comprising

means for positioning a data transducer to write data on and read data from said media; and

means for recording a data on at least some of the tracks a first time using a first encoding method and a second time using a second encoding method, said second encoding method being different from said first encoding method.