Specification

Title of the Invention:

Disk drive device, error recovery processing method therefor, and disk drive controller

Detailed Description of the Invention:

[Field of the invention]

The present invention relates to a disk drive device, an error recovery processing method thereof, and a disk drive controller that can contribute to maintenance of recording capacity and to enhancement of reliability.

[0002]

[Background art]

A disk drive device using a magnetic disk as a recording medium uses a head for recording and reproducing data on the magnetic disk. This head is installed under the bottom surface (the surface in the magnetic disk side) of a head slider having an air bearing surface in the magnetic disk side. The head slider is installed at an end of a head arm, which moves the head slider toward the nearly radial direction of the magnetic disk by being rotatably driven by a rotary actuator.

[0003]

In addition, the head slider is energized toward the magnetic disk by an elastic member installed in the head arm. When air flows into between the head slider and magnetic disk with the rotation of the magnetic disk, the head slider floats from a magnetic disk surface with resistance to an energizing force of the elastic member. A gap between the magnetic disk and head slider is a predetermined value determined with relative speed between the air bearing surface and magnetic disk as a factor.

[0004]

By the way, a portion where a gap between the head and magnetic

disk becomes small may sometimes occur because the head slider or head is deformed by thermal expansion or the like and a specific portion protrudes toward the magnetic disk.

[0005]

On the other hand, a certain degree of thermal asperity may be formed on a surface of the magnetic disk with depending on machining accuracy.

[0006]

Owing to this, if the portion where the gap between the head and magnetic disk becomes small occurs as described above, this portion may collide with the thermal asperity on the surface of the magnetic disk. If such collision occurs, the temperature of the head sharply increases due to frictional heat and the like.

[0007]

In particular, in regard to a head using an MR (magnetoresistance effect) element or a GMR (giant magnetoresistance effect) element, since an increase of the head temperature leads to a large change of a reproduced signal, reliability of recording and reproducing is largely decreased. In some cases, recording and reproducing cannot be performed.

[0008]

For this reason, conventionally, there are disk drive devices where countermeasures such as correction of a head output caused by the temperature change with using a DC component of the reproduced output of the head are devised. Nevertheless, there are many cases that it is not sufficient only to correct the head output at the time of the thermal asperity occurring.

[0009]

In addition, there is an area where the thermal asperity occurs permanently. Therefore, for example, as disclosed in Published Unexamined Patent Application No. 9-251727, there are disk drive devices where each area where the thermal asperity occurs permanently is not used for recording and reproducing as a defective sector.

[0010]

Furthermore, conventionally, since positional information of a head is detected on the basis of a reproduced output from servo sectors, recording and reproducing of data cannot be performed if a servo sector just before a data sector is not correctly reproduced due to the thermal asperity.

[0011]

For this reason, it is devised to perform recording and reproducing by estimating a head position with using appropriate positional information such as a reproduced output from a previous servo sector even if a servo sector just before a data sector is not correctly reproduced.

[0012]

[Problems to be solved by the invention]

Nevertheless, it may be possible to perform recording and reproducing even in an area, which has been designated as an area where the thermal asperity has occurred permanently, so long as head temperature falls thereafter. Therefore, if the area, which has been designated as an area where the thermal asperity has occurred permanently, is uniformly designated as a defective sector, this increases defective sectors unnecessarily, making spare sectors decrease.

[0013]

In addition, in particular, at the time of recording, correct positional information of a head is necessary from the viewpoint of reliability and the like. Hence, there is a room for improvement from the viewpoint of reliability in regard to using proper positional information as described above.

[0014]

The present invention is performed in consideration of the above problems and is to provide a disk drive device, an error recovery processing method thereof, and a disk drive controller that can contribute to maintenance of recording capacity and to enhancement of reliability.

[0015]

[Summary of the invention]

A disk drive device according to the present invention comprises a disk recording medium, recording and reproducing means for recording and reproducing information on the disk recording medium, error detecting means for detecting an error occurring during recording or reproducing by the recording and reproducing means, means for executing error recovery procedure by controlling the recording and reproducing means when the error detecting means detects an error, and error processing means for recording and reproducing again on an area where the error had occurred after predetermined time (waiting time) elapsed if the error had been not recovered by the execution of error recovery procedure.

[0016]

In addition, a disk drive device can comprise temperature detecting means for detecting temperature inside the disk drive device or outside the disk drive device, wherein the error

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processing means sets the waiting time according to the temperature detected.

[0017]

Furthermore, a disk drive device can comprise alternative area assigning means for designating an area where an error occurred as an error area if the error is not recovered even if the error processing means performs recording or reproducing again, performing temporary registration, and assigning an alternative area, temporary registration confirming means for performing recording or reproducing again on the area having been designated as an error area after the temporary registration was performed and the predetermined time elapsed, and canceling the temporary registration if the error is recovered or changing the temporary registration to regular registration if the error is not recovered.

[0018]

In addition, an error recovery processing method of a disk drive device according to the present invention comprises a write error detecting step of detecting an error during recording or reproducing information on a disk recording medium, an error recovery step of executing error recovery procedure when an error is detected at the write error detecting step, and a error processing step of performing recording or reproducing again after predetermined time (waiting time) elapsed if the error had not been recovered even at the error recovery processing step.

[0019]

[Preferred embodiment]

Figure 1 is a block diagram showing the construction of a disk drive device that is an embodiment to which the present invention is applied.

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[0020]

This disk drive device comprises: a magnetic disk 1 for recording data; memory 2 for storing a control program, and recorded and reproduced data; a controller 3 controlling the operation of the entire disk drive device, and input and output of data with a host system 10 such as an external personal computer; a recording and reproducing system 4 performing recording and reproducing on the magnetic disk 1 on the basis of the control by the controller 3; a servo system 5 controlling positions for recording and reproducing by the recording and reproducing system 4 on the basis of the control by the controller 3; a head 6 for performing recording and reproducing on the magnetic disk 1; a head drive mechanism 7 moving the head 6 on the basis of the control by the servo system 5; a temperature sensor 8 detecting temperature of the outside or inside of the disk drive device; and an AD converter (ADC) 9 performing AD conversion of the output of the temperature sensor 8.

[0021]

In the memory 2, an area where recorded and reproduced data, a control program for the controller 3, data (for example, a reassignment table and the like), etc. are stored, and a buffer area where recorded and reproduced data are stored are provided. The buffer area has capacity capable of saving data, whose number is equal to or more than several hundreds units in the recording unit (data sector), on the magnetic disk 1.

[0022]

The controller 3 comprises a processor that executes the control program, a hard disk controller, and the like. This controller 3 controls the operation of the entire disk drive device by executing the control program stored in the memory 2. Furthermore, the controller 3 controls recording and reproducing on the magnetic disk 1 on the basis of commands and

data that are supplied from the host system 10.

[0023]

The controller 3 can execute a plurality of processes in parallel, and hence performs the control of input and output of commands and data with the host system 10, the cache control of recorded and reproduced data, the servo control of a position of the head 6, and the like.

[0024]

The head 6 comprises, for example, an inductance type recording head, and a reproducing head using, for example, an MR (magnetoresistance effect) element or a GMR (giant magnetoresistance effect) element.

[0025]

On a recording surface of the magnetic disk 1, plenty of recording tracks are formed, for example, in the radial direction. On each of these tracks, data sectors whose number depends on a position in the radial direction and the like are recorded, and recording and reproducing is performed with this data sector as the unit. On the other hand, recording and reproducing is instructed with a predetermined logic block address (LBA) instead of the data sector unit from the host system 10. Therefore, the controller 3 performs conversion between the LBA, which is instructed by the host system 10, and the data sector with using, for example, as shown in Figure 2, a table (a conversion table) showing the correspondence of each LBA and each data sector.

[0026]

Hereinafter, the operation of the disk drive device constructed like this will be described.

[0027]

In recording tracks on the magnetic disk 1, a servo sector is recorded per predetermined angle (for example, 360°/66) for identifying each track, detecting a tracking error, or the like. The recording and reproducing system 4 obtains a position of the head 6 from the reproduced output of a servo sector supplied by the head 6 and supplies the positional information to the controller 3.

[0028]

In addition, the controller 3 obtains a recording track, where a corresponding data sector is recorded, from an LBA instructed by the host system 10, and obtains a positional error (PES) with comparing to the position of the head 6 supplied by the recording and reproducing system 4. Then, the controller 3 moves the head 6 to a target recording track (target track) with controlling the servo system 5 according to this PES.

[0029]

When the head 6 is moved to the target track, the controller 3 instructs recording or reproducing at the timing when a data sector corresponding to the LBA instructed by the host system 10 is reproduced. Owing to this, recording or reproducing is performed on the predetermined data sector instructed by the host system 10.

[0030]

By the way, during use of the disk drive device, an area (error area) where normal recording and reproducing cannot be performed on a recording surface of the magnetic disk 1 may occur. Owing to this, a spare area is provided on a recording surface beforehand, and, if an error area occurs, a data sector (a spare sector, for example, a data sector on the most inner track) in the spare area is assigned instead of the data sector

in the error area. Therefore, recording and reproducing can be performed as if an error did not occur, with looking from the host system 10.

[0031]

Such assignment of a spare sector is managed with, for example, a reassignment table shown in Figure 3. This reassignment table, as shown in Figure 3, includes LBAs (LBA) corresponding to data sectors to which spare sectors are assigned, spare sector numbers (SPARE) corresponding to these LBAs, and flags (CAN, RE, WE, PRE, and TACAN) showing states of assignment.

[0032]

When recording or reproducing is instructed with an LBA being supplied by the host system 10, the controller 3 refers to this reassignment table and checks whether a spare sector is assigned to a data sector corresponding to the LBA instructed. If a spare sector is not assigned, the controller 3 refers to the conversion table shown in Figure 2, obtains the sector number of the data sector corresponding to the LBA instructed. Furthermore, the controller 3 makes the recording and reproducing system 4 execute recording or reproducing operation on the data sector corresponding to the sector number obtained, with controlling the operation of the recording and reproducing system 4. On the other hand, if a spare sector is assigned to the data sector corresponding to the LBA instructed, the controller 3 makes the recording and reproducing system 4 execute recording or reproducing operation on the spare sector assigned, with controlling the operation of the recording and reproducing system 4.

[0033]

In addition, when recording or reproducing is performed, the recording and reproducing system 4 detects whether the recording or reproducing on the magnetic disk 1 is normally

terminated, and supplies the detection result to the controller 3.

[0034]

Figure 4 is a flow chart showing the operation at the time of performing data recording. When data recording is instructed by the host system 10 with data to be recorded and an LBA being supplied, the operation is started from step S1 in Figure 4.

[0035]

First, at step S1, the controller 3 instructs data recording with supplying the data to be recorded to the recording and reproducing system 4 at the predetermined timing, and the process goes to the subsequent step S2. Owing to this, the recording and reproducing system 4 records the data to be recorded on the predetermined data sector of the magnetic disk 1, and supplies to the controller 3 the information showing whether this recording is terminated.

[0036]

At the step S2, the controller 3 judges whether writing is normally terminated, and, if normally terminated, the recording operation is completed. If a certain error occurs and the recording is not normally terminated, the process goes to step S3 to execute error recovery procedure (ERP).

[0037]

In this ERP, the controller 3 repeats recording several times with changing, for example, an offset from the reference position of the head 6 by controlling the servo system 5, or recording parameters such as the filtering property of the recording and reproducing system 4 described above.

[0038]

After completion of such ERP, the process goes to step S4, the recording operation is completed if the recording is normally terminated by means of the ERP and the error is recovered. Nevertheless, if the recording fails predetermined times or more, the process goes to step S5, and the process goes to step S6 after waiting for a predetermined time (waiting time) at the step S5 to perform recording again. Furthermore, the process goes to step S7.

[0039]

In this manner, if the cause of the error is sharp increase of the temperature of the head 6 due to collision of a protrusion caused by the thermal expansion of the head 6 with a thermal asperity on the surface of the magnetic disk 1, it becomes possible to perform normal recording by performing the recording again. It is because the temperature of the head 6 falls during the waiting time and the gap between the protrusion of the head 6 and the surface of the magnetic disk 1 becomes large.

[0040]

Figure 5 is a graph showing the change of the frequency of error occurrence depending on temperature in a disk drive device and waiting time. It can be seen from Figure 5 that, if the temperature inside the disk drive device is high, lowering of the frequency of error occurrence is slow, and, if the temperature inside the disk drive device is low, lowering of the frequency of error occurrence is fast.

[0041]

Therefore, by setting the waiting time (the waiting time is set long if the temperature is high, and short if low) on the basis of the data showing the temperature inside the disk drive

device that is supplied from the temperature sensor 8 through the ADC 9, it becomes possible to optimize the balance between the lowering of performance due to the waiting time and the enhancement of recording-reliability.

[0042]

Furthermore, at step S7, the controller 3 judges whether the re-recording is normally terminated, and, if normally terminated, the recording operation is completed. On the contrary, if a certain error occurs and the recording is not normally terminated, the process goes to step S8. At the step S8, the controller 3 designates the data sector which performed the recording as a defective sector, temporarily assigns a spare sector to become a substitute, and records data in this spare sector. Furthermore, the controller 3 records the LBA corresponding to the data sector, to which the spare sector is assigned, and the number of the spare sector, being assigned, in the above-described reassignment table and appropriately sets the flag showing that an error is occurred to terminate this process. In this case, the controller 3 sets to 1 the flag WE showing that the error is an error during recording and the flag TACAN showing that the assignment is temporary. In addition, if an error occurs during reproducing and temporary registration is performed, the controller 3 sets to 1 the flag RE showing that the error is an error during reproducing and the flag TACAN showing the assignment is temporary.

[0043]

This reassignment table is recorded in, for example, a predetermined area on the magnetic disk 1, or non-volatile memory provided in the controller 3. Furthermore, the same table as this is saved in memory of the controller 3 for acceleration of operation when a fixed disk operates.

[0044]

In this manner, by assigning a spare sector to a sector designated as a defective sector, hereinafter, recording and reproducing is performed to the spare sector assigned, when the recording and reproducing to the defective sector is requested.

[0045]

In addition, if a read error occurs during reproducing data, the operation similar to the operation in Figure 4 is executed. The difference between them is that reproducing is performed instead of recording at the steps S2 and S6, and ERP, and that the controller 3 sets the flag RE to 1 instead of the flag WE when temporary registration is performed at the step S8.

[0046]

As described above, in this disk drive device, it is possible to perform recording and reproducing with avoiding an error caused by a temperature increase of the head 6 by performing recording or reproducing again to a data sector, where the error had occurred during recording or reproducing, after a predetermined waiting time elapsed, if the error had been not recovered in spite of executing the error recovery procedure.

[0047]

Therefore, it is possible to prevent the decrease of recording capacity by preventing unnecessary assignment of spare sectors. In addition, since it is possible to perform recording and reproducing, which is similar to normal recording and reproducing, by avoiding an error due to the temperature increase of the head 6, it is possible to increase reliability in comparison with a case of performing recording and reproducing with using appropriate positional information.

[0048]

By the way, it may become possible to perform normal recording and reproducing on the data sector, to which a spare sector has temporarily been assigned as described above, when the temperature of the head 6 falls after time in some extent elapsed. If this state is left as it is, spare sectors are unnecessarily consumed, and hence, this leads to shortage of spare sectors, lowering of access speed, and the like.

[0049]

Generally, the shortage of spare sectors arises due to limitation of the number of spare sectors. Generally, the lowering of access speed arises because the spare sectors are provided in the most inner track and the head 6 should be moved to the track, where spare sectors are provided, every time recording or reproducing to a data sector to which a spare sector is assigned is instructed.

[0050]

Then, this disk drive device confirms the temporary registration to the data sector, where a spare sector has been temporarily assigned as described above, after predetermined time from the temporary registration elapsed. If normal recording can be performed, the temporary registration is deleted, and, if not, this disk drive device changes the temporary registration to regular registration.

[0051]

Figure 6 is a flow chart showing the confirmative operation of this temporary registration. The confirmative operation of this temporary registration includes counting the time after the controller 3 performs the temporary registration in Figure 2, being activated after predetermined time elapsed, and starting execution from step S11 in Figure 6. Alternatively,

the operation can include confirming at the time of startup whether I/O operation with the host system 10, or other operation, which has large load or is important, such as the ERP described above is being executed, and being started after completion of this operation if this operation is being executed. In addition, the controller 3 can start the confirmative operation of the temporary registration every certain period.

[0052]

First, at the step S11, the controller 3 confirms the reassignment table shown in Figure 3 described above. Furthermore, the controller 3 confirms whether the data sector, which was temporarily registered at the step S8 in Figure 4 described above, exists, that is, whether a data sector, whose TACAN flag in the reassignment table is 1, exists. If the temporary registration does not exist, the confirmative operation is completed, and, if exists, the process goes to the subsequent step S12.

[0053]

Next, at the step S12, the controller 3 instructs the recording and reproducing system 4 to reproduce data in the spare sector and to record the reproduced data in the original data sector, to which an alternative sector has been assigned by the temporary registration, at the next step S13. Then, the process goes to the next step S14.

[0054]

At the step S14, the controller 3 judges whether the recording is normally terminated, and, if normally terminated, the process goes to step S15 to complete the confirmative operation of the temporary registration after cancellation of the temporary registration. Concretely, the controller 3 deletes the data relating to the data sector in the reassignment table

described above. Owing to this, the temporary registration is cancelled, the data sector is treated as a defect-free data sector, and the spare sector assigned to this data sector also is released. Owing to this, since the temporary registration of the data sector becomes regular registration, recording and reproducing is performed to the spare sector assigned to the data sector.

[0055]

On the contrary, if the recording is not normally terminated at the step S14, the process goes to step S16, and the controller 3 changes the temporary registration to regular registration to complete the confirmation. Concretely, the controller 3 resets the flag TACAN in the reassignment table, described above, to 0. As described above, since the controller 3 not only sets the flag WE or RE to 1 but also sets the flag TACAN to 1 at the time of the temporary registration, only the flag WE or RE keeps 1 by resetting the flag TACAN to 0. Hence, hereinafter, the registration regarding the data sector is treated as regular registration.

[0056]

In addition, the controller can judge before completion of the confirmative operation of the temporary registration whether other temporary registration exists, reexecute the operation from the step S11 if exists, and terminate the operation if not.

[0057]

By confirming temporary registration in regard to sectors temporarily registered like this, it is possible to use sectors, where normal recording and reproducing can be performed if the temperature of the head 6 falls, among sectors, which have been temporarily registered as defective sectors, as defect-free sectors. Owing to this, it is possible

to prevent the memory capacity of a disk drive device from unnecessarily decreasing. In addition, since it is possible to release spare sectors assigned by the temporary registration, it is possible to resolve shortage of spare sectors, lowering of access speed, and the like.

[0058]

In addition, the present invention is not limited to the embodiments described above. For example, although cases that the present invention is applied to disk drive devices are described in the embodiments, application objects of the present invention are not limited to disk drive devices, but can be other disk recording media such as an magneto-optical disk. Therefore, it is possible to perform necessary modification within the scope of technical idea of the present invention.

[0059]

[Advantages of the invention]

According to the present invention, it is possible to perform recording and reproducing with avoiding an error caused by a temperature increase of recording and reproducing means by performing recording or reproducing again on an area, where the error had occurred during recording or reproducing, after a predetermined time elapsed, if the error had been not recovered in spite of executing error recovery procedure. Therefore, it is possible to contribute to maintenance of recording capacity and enhancement of reliability.

[0060]

In addition, by confirming temporary registration in regard to an area temporarily registered, canceling the temporary registration if an error is recovered, and changing the temporary registration to regular registration if not

recovered, it is possible to use areas, where normal recording and reproducing can be performed if the temperature of the recording and reproducing means falls, among areas, which have been temporarily registered, as defect-free areas. Therefore, it is possible to prevent the recording capacity of a disk drive device from unnecessarily decreasing.

4. Brief Description of the Drawings:

Figure 1 is a block diagram showing the construction of a disk drive device that is an embodiment of the present invention;

Figure 2 is a drawing showing an example of a conversion table showing correspondence between the logic block address (LBA), which is supplied by a host system, and the data sector;

Figure 3 is a drawing showing an example of a reassignment table;

Figure 4 is a flow chart showing error recovery procedure at the time when thermal asperity caused by expansion of a head occurs;

Figure 5 is a graph showing the change of the frequency of error occurrence corresponding to temperature in a disk drive device and waiting time; and

Figure 6 is a flow chart showing the confirmative operation of temporary registration.

[Description of symbols]

1 ... Magnetic disk
2 ... Memory
3 ... Controller
4 ... Recording and reproducing system
5 ... Servo system

6 ... Head
7 ... Arm
8 ... Temperature sensor
10 ... Information processor

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Claims:

(1) A disk drive device comprising:

a disk recording medium;

a recording and reproducing device for recording and reproducing information on the disk recording medium;

an error detector for detecting an error occurring during recording or reproducing by the recording and reproducing device;

a device for executing error recovery procedure by controlling the recording and reproducing device when the error detector detects an error; and

an error processor for performing recording or reproducing again on an area, where the error had occurred, after predetermined time (waiting time) elapsed if the error had not been recovered by the execution of error recovery procedure.

(2) The disk drive device according to Claim 1, further comprising:

a temperature detector for detecting temperature inside the disk drive device or outside the disk drive device, wherein the error processor sets waiting time according to

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* C L M S *

temperature detected by the temperature detector.

(3) The disk drive device according to Claim 2, wherein the error processor sets waiting time in a case that temperature detected by the temperature detector is higher than predetermined temperature longer than waiting time in a case that temperature detected by the temperature detector is lower than the predetermined temperature.

(4) The disk drive device according to Claim 1, wherein the error processor comprises:

an alternative area assigning device for designating an area, where an error occurred, as an error area if the error is not recovered even if the recording or reproducing is performed again, performing temporary registration, and assigning an alternative area;

a temporary registration confirming device for performing recording or reproducing again on the area, having been designated as an error area, after temporary registration was performed by the alternative area assigning device and predetermined time elapsed, and canceling the temporary registration if the error is recovered or changing the temporary registration to regular registration if the error is not recovered.

(5) The disk drive device according to Claim 4, wherein the alternative area assigning device records information, showing correspondence between the error area and the alternative area, and identification information, showing that the area has been temporarily designated as the error area, in a reassignment table when assigning the alternative area; and

wherein, on the basis of the reassignment table, the temporary registration confirming device executes recording or reproducing again to the area having been

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designated as the error area, confirms error recovery, and cancels temporary registration or changes to regular registration.

(6) An error recovery processing method of a disk drive device, comprising:

a write error detecting step of detecting an error occurring during recording or reproducing information on a disk recording medium;

an error recovery step of executing error recovery procedure when an error is detected at the write error detecting step; and

an error processing step of performing recording or reproducing again after predetermined time (waiting time) elapsed if the error had not been recovered even by the execution of error recovery procedure.

(7) An error recovery processing method of the disk drive device according to Claim 6, comprising:

an alternative area assigning step of designating an area, where an error occurred, as an error area if the error is not recovered at the error processing step, performing temporary registration, and assigning an alternative area; and

a temporary registration confirming step of performing recording or reproducing again on the area, having been designated as an error area, after temporary registration was performed at the alternative area assigning step and predetermined time elapsed, and canceling the temporary registration if the error is recovered or changing the temporary registration to regular registration if the error is not recovered.

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(8) A disk drive controller comprising:

an error detector for detecting an error occurring during recording or reproducing by a recording and reproducing device recording and reproducing information on a disk recording medium;

a device for executing error recovery procedure by controlling the recording and reproducing device when the error detector detects an error; and

an error processor for recording or reproducing again on an area, where the error had occurred, after predetermined time (waiting time) elapsed if the error had not been recovered by the execution of error recovery procedure.

(9) The disk drive controller according to Claim 8, wherein the error processor comprises:

an alternative area assigning device for designating an area, where an error occurred, as an error area if the error is not recovered even if the recording or reproducing is performed again, performing temporary registration, and assigning an alternative area; and

a temporary registration confirming device for performing recording or reproducing again on the area, having been designated as an error area, after temporary registration was performed by the alternative area assigning device and predetermined time elapsed, and canceling the temporary registration if the error is recovered or changing the temporary registration to regular registration if the error is not recovered.

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