Western Digital

Protege, Caviar, Caviar SE
Generation electronics Arch-V, Arch-VI on chip WD70Cxx
WDxxxxAB/EB/BB/JB/LB/PB

Contents:

1. Purpose

As a part of the PC-3000 hardware and software complex for Windows, this utility is designed for maintenance of Protégé, Caviar, and Caviar SE HDD manufactured by Western Digital using WD70Cxx-based electronics (Arch-V, Arch-VI), namely the WDxxxAB, WDxxxEB, WDxxxxBB, WDxxxxJB, WDxxxxLB, and WDxxxxPB drive families.

2. Basic options for repair of WD drives

This utility of the PC-3000 complex for Windows intended for maintenance of WD «Protégé», «Caviar», and «Caviar SE» HDD (Arch-V and Arch-VI WD70Cxx-based architecture, i.e. drive families WDxxxAB/EB/BB/JB/LB/PB) supports the following features:

- Drive testing in techno mode
- Testing and restoration of HDD firmware
- Reading and writing of parallel and serial Flash ROM in HDD
- Reviewing and checking of the firmware structure (available in an interactive mode as well)
- Low-Level Format
- Reviewing the G-List and P-List tables of hidden defects
- Addition of revealed defects to P-List G-List
- Translator regeneration;
- Modification of configuration parameters in HDD ID
- Resetting of S.M.A.R.T. and error logs
- Initiation of internal HDD SelfScan routine and monitoring of its status.

3. Getting started

While preparing for work with a WD HDD, you should identify the architecture of the drive (based on WD70Cxx or Marvell 88i554x (88i654x)), the type of Flash ROM installed in it (parallel or serial) and the settings of its configuration jumpers. The utility supports WD70Cxx-based WD HDD with all configuration jumpers disabled or set to the «Single or Master» position (do not confuse with the «Master with slave present» mode).

The utility will be more efficient when used in combination with the PC-3K PWR power supply adapter installed on the PC-3000PCI board and an additional power supply (a standard PC power supply unit can be used), the case must be connected by a conductor to the case of the computer where the PC-3000PCI tester board is installed. That is necessary to equalize the ground potentials.

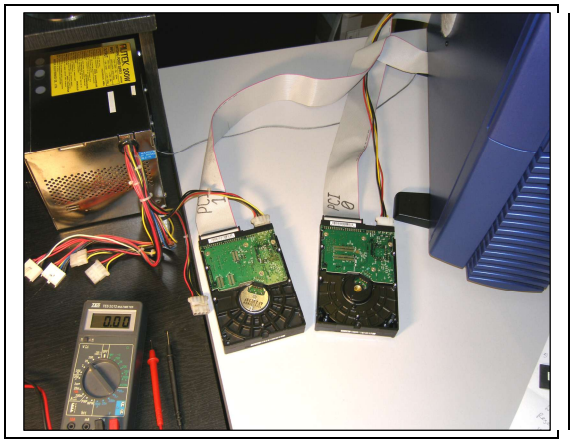


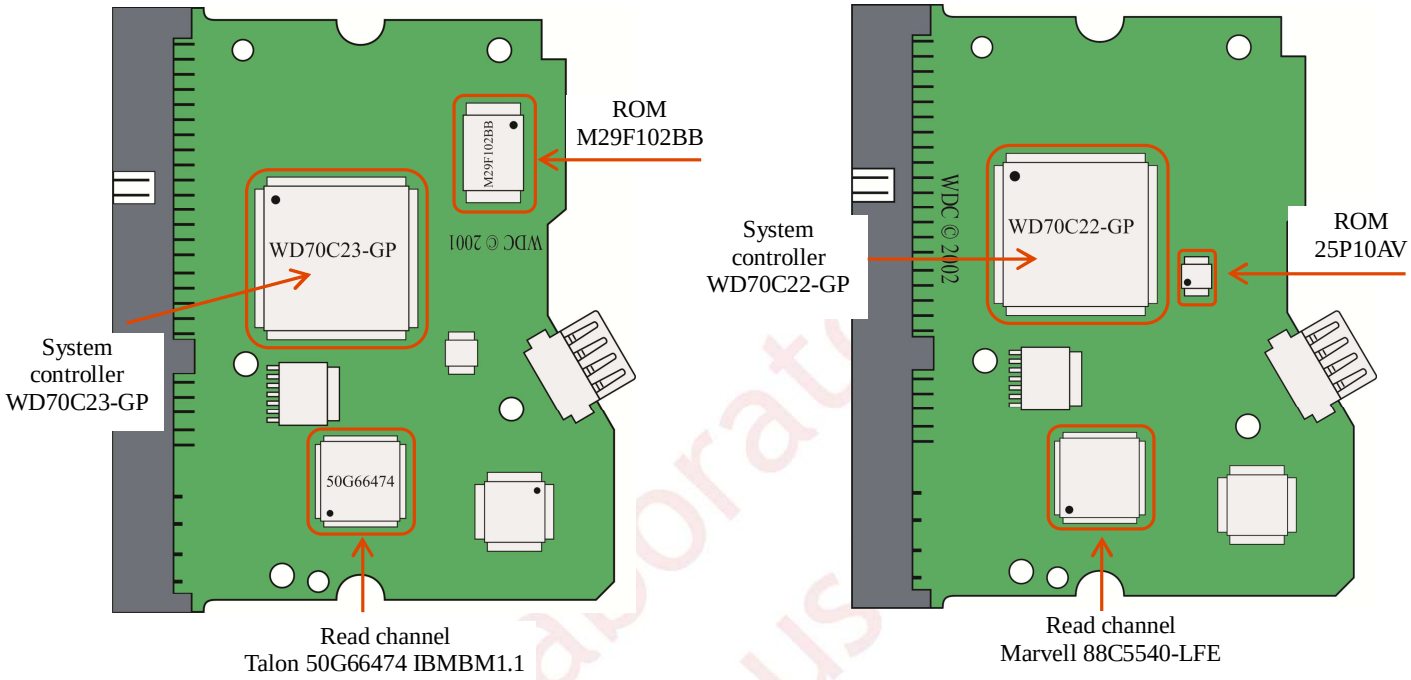
Fig. 3.1. A photograph of possible workspace organization.

Attention! Utility tests have numerous settings. Novice users are advised to work with the default settings.

4. Architecture review of WD HDD

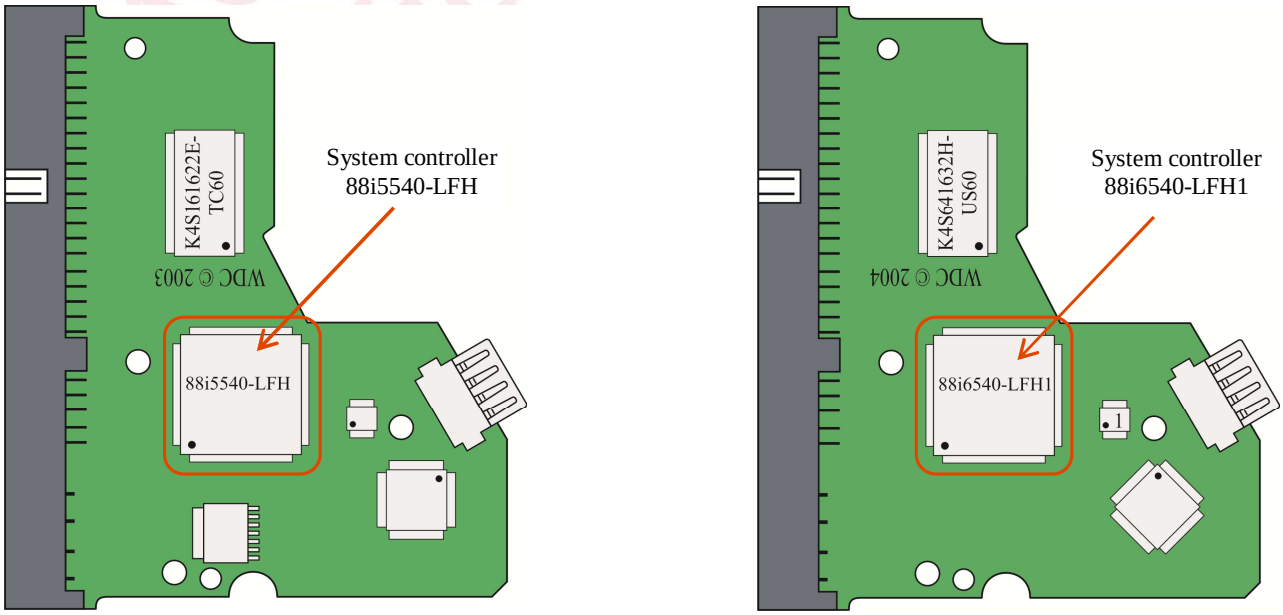
Western Digital at present manufactures two lines of drives, which differ considerably.

The first line stems from Arch-0 WD drives belonging to the WDC AC280 (80 Mb) family, these drives use a classical WD architecture based on system controller designed by the manufacturer. Here belong WD70Cx-based HDD of Arch-V and Arch-VI families with maximum model capacity of 240 Gb reached in Arch-VI drives:



Layout scheme of two WD70Cx-based controller boards

The second line is based on a completely different architecture using Marvell 88i554x or 88i654x system controller chip. Therefore, the manufacturer used completely different technological commands and the principle of work with the service area resulting in another technology necessary for restoration of those drives. They can be identified visually by their L-shaped PCBs:



Layout scheme of two Marvell-based controller boards

5. Using the utility

After start the utility displays the following mode selection menu:

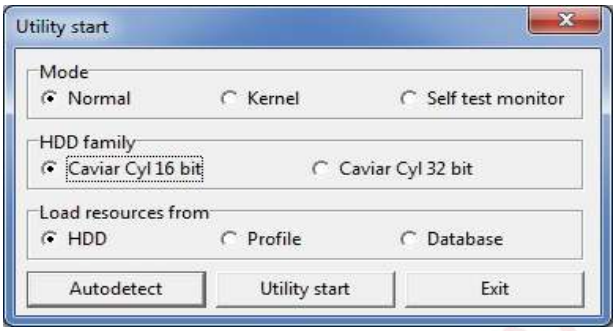


Fig.5.1. Utility start

- ***Normal*** – the main mode of utility operation provided that the drive has been initialized successfully. All configuration (Single or Master mode) jumpers must be disabled on a HDD in that mode.
- ***Kernel*** – the mode intended for work exclusively with the electronics board (PCB) without head-and-disk assembly (HDA). HDD enters the «Kernel» mode when three of its jumpers are enabled simultaneously: CS, SLAVE and MASTER.
- ***Self test monitor*** – the mode is intended for monitoring of the Selfscan procedure progress after its launch.

HDD family selection allows utility configuration for work with WD Arch.V (Caviar Cyl 16 bit) or WD Arch.VI (Caviar Cyl 32 bit) drives respectively. The «Autodetect» button performs automatic utility configuration; in that case you should select the «Normal or Kernel» mode first.

5.1. Normal mode

When the utility starts in the *Normal* mode, it sends the technokey, reads physical HDD parameters, ROM contents and configuration modules from the service area. The utility outputs all information pertaining to initialization progress to its log.

After the procedure the utility will be able to perform its testing functions available from the «Tests» and «Tools» menus. The remaining items of the «Mode», «User tests», «Windows», etc. are common for all utilities of the PC-3000 package for Windows; they are described in the documentation for the universal utility.

5.1.1. «Tests» menu

The «Tests» menu consists of the following items:

- Utility status
- Service information
- Format
- Logical test
- Defect list
- Clear S.M.A.R.T.

5.1.1.1. Utility status

Selection of that menu item brings up a form consisting of three sections: «Utility, HDD ID», and «HDD parameters».

The «Utility» section reminds the user of the mode that the utility is running in.

The «HDD ID» section displays the main parameters of the connected drive. These are the parameters used as criteria for addition of the resources copied from a drive to the «Database» and for subsequent search for compatible resources in it. All fields of that section will be read and filled in automatically except for the DCM field, which you are

advised to fill in manually with the DCM number from the head-and-disk assembly case of the HDD. When working with a drive with Flash ROM installed the «ROM version», «ROM generation», and «Link table version» fields will contain the */Serial ROM/* string. It appears because that ROM type does not contain information about the version.

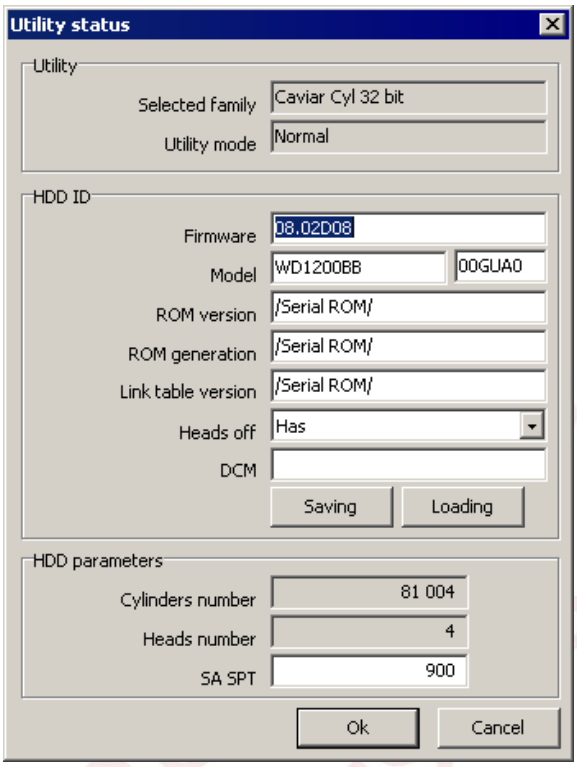


Fig. 5.2. Utility status

The section also includes two buttons: «Save» and «Load». They can be used to store all previously read parameters to a drive's profile or load them from it. The option helps avoid entering DCM manually each time you start the utility with the same HDD. It is also necessary in cases, when a HDD suddenly stops to read its ID parameters although it could read them earlier.

The «HDD parameters» section demonstrates physical parameters of a drive. The value of the «SA SPT» field (number of sectors per track in the service area) can be modified. The opportunity is provided to allow work with the service area of damaged drives, which fail to identify the value automatically.

5.1.1.2. Service information

The submenu allows access to the following modes:

- HDD resources backup
- Work with ROM
- Work with service area
- Work with database

5.1.1.2.1. HDD resources backup

The option allows you to backup all resources accessible on the current drive to its profile folder. Thus, if necessary, you will be able to restore the service data of the HDD later and return the drive to its original state.

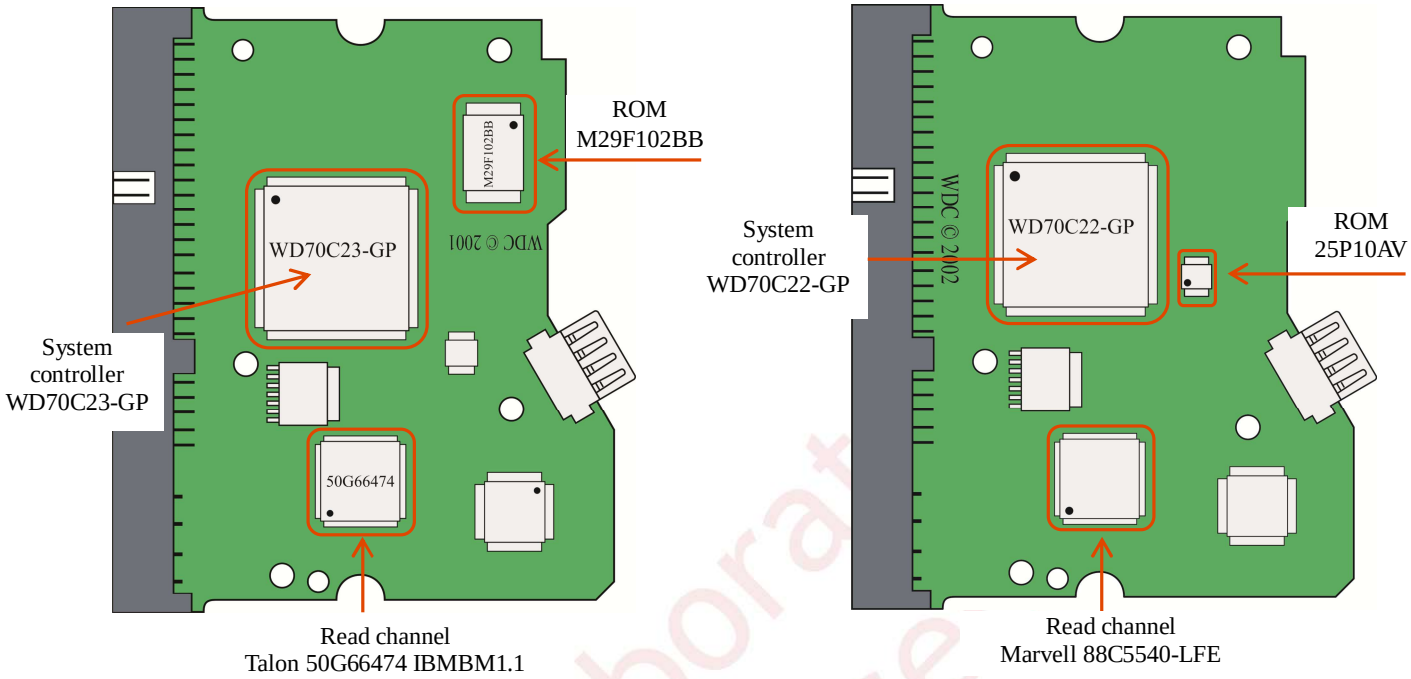
Attention! It is recommended to backup HDD resources before you start working with it.

5.1.1.2.2. Work with ROM

The menu serves for work with drive ROM - reading, writing and viewing service information preserved in ROM. You can also use the mode to correct the map of active magnetic heads, which is stored in ROM, too.

WD Arch-V *(Caviar Cyl 16 bit)* drives use M29F102BB parallel Flash ROM chips in TSOP-40 package. In some drives the manufacturer uses M27C1024 one-time-programmable ROM chips in TSOP-40 package, which does not support reprogramming. Both chips are compatible and can replace each other, when necessary.

WD Arch-VI *(Caviar Cyl 32 bit)* drives employ 25P10AV serial Flash ROM chips in SOIC-8 package.



View ROM information.

The command outputs to log service information pertaining to a part of HDD firmware stored in ROM: ROM version, ROM generation, link table version, head map and the list of supported models. For WD Arch-VI *(Caviar Cyl 32 bit)* with serial Flash ROM the utility outputs no information about the version and supported models since their ROM contains no such data.

Head map changing.

The mode allows you to perform software disabling of magnetic heads or reactivate previously disabled heads in a HDD. Selection of the mode makes the utility read the ROM contents and display a form where you can edit the map of heads:

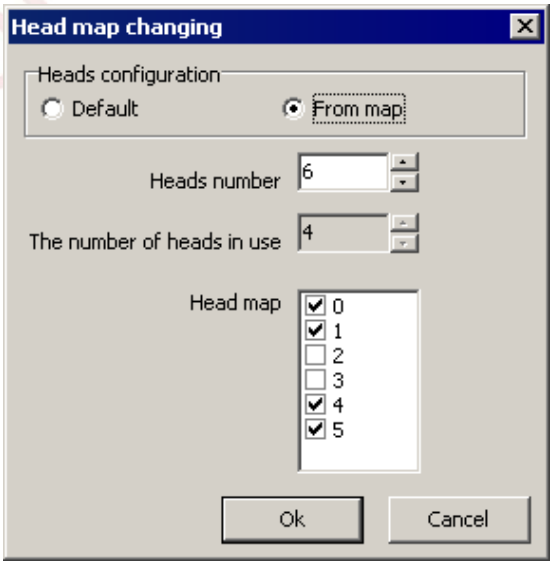


Fig. 5.3.

- The «Heads configuration» section defines the source of information about the map of heads used by the drive in operation. The «Default» configuration setting means that the head map is generated during HDD initialization and includes the heads physically connected to the preamplifier-commutator chip. Selection of the From map distribution option disables the internal polling of connected heads. In that case the drive will not rely upon the information about physically connected heads. Instead, it will use the head map in ROM.
- The «Heads number» parameter defines the highest number of heads for the current type of magnetic heads assembly. The number does not take disabled heads into account; its value may be equal to 6, 4 or 2 although the actual number of used heads may be smaller.
- «The number of heads in use» parameter is set automatically depending upon the number of selected heads in the «Head map» field.
- The «Head map» field defines the numbers of physical heads that the drive will use in its operation. You can use the field to disable or activate previously disabled heads.

After completion of corrections, the generated head map will be written to the drive's Flash ROM.

ROM reading.

Command reads ROM contents to a file. When selecting the procedure, you will have to specify the destination for the resulting file – «HDD profile» or the «database» containing HDD resources. If necessary, you can change the default ROM file name.

Writing ROM[1].

The command writes drive's Flash ROM from a file. You have to specify first the source of the original file for recording («HDD profile» or the «database» containing HDD resources). Then for WD Arch-V (Caviar Cyl 16 bit) drives you will need to specify the source of the loader to use: «Module 61h» of the drive's service area or «Internal utility loader». Then the utility performs actual recording of Flash ROM taking several seconds. If after recording the utility outputs a ROM writing error to log, perhaps, the drive is based on a one-time-programmable ROM chip.

With WD Arch-VI *(Caviar Cyl 32 bit)* drives using Serial Flash ROM the recording procedure is performed in two stages. First you should load to the drive a recording program and then the actual writing process will start. It may take up to 20 minutes. Please see details on ROM «recording in section 10».

5.1.1.2.3. Work with service area

The menu allows manipulations with the service area, which is located on cylinders with negative numbers inside a HDA; it will be discussed in «detail in section 6.1».

5.1.1.2.4. Work with database

The menu allows creation (addition to the Database) of «master HDD resources» read from known good drives and и «export of resources» for exchange between the users of the PC-3000 complex for Windows. Work with the database is described in more detail in the general documentation.

5.1.1.3. Format

The command initiates Low-Level Self Format procedure. Prior to beginning, you will be offered to select the method that the drive should use: include the contents of the P-List and (or) G-List defect tables or ignore these lists. Depending upon that choice, the drive will regenerate its translator at the start of the formatting procedure and then actually format the platters in accordance with the translator tables. In the process, the drive skips defective sectors and defective tracks specified in the translator tables. Upon format completion, all sides will be formatted taking into account the translator tables. Formatting takes approximately 40 minutes; it depends upon the model, condition of the magnetic platters and it may grow if the surfaces are defective. The formatting procedure cannot be interrupted because otherwise the surfaces will be formatted incompletely. If format reveals tracks with corrupted servo labels, the procedure will interrupt and return an error. If such error occurs in the first second after formatting start, it means that the original P and (or) G-List are damaged and therefore prevent translator regeneration. In that case you may attempt to recalculate translator or launch format ignoring the defect lists or try to analyze their possible corruption in defect editor.

[1] – The operation is only possible with HDD models using Flash ROM.

5.1.1.4. Logical test

This menu item starts the procedure scanning for defects using logical parameters in LBA mode. The procedure and its settings are identical to the logical scanning procedure in the universal utility. However, there are some guidelines pertaining to the use of «additional» logical scanning settings as applied to the WD utility (please see section 6.2 for details).

5.1.1.5. Defect list

This menu provides access to operations with the drive's defect lists: Primary – P-List and Grown – G-List. P-List is generated at the manufacturing factory during HDD testing, while G-List remains initially empty.

During operation, a drive independently adds revealed defects to G-List. It happens during selftesting when the drive is not accessed by its host computer (the mode is referred to as Data Lifeguard™) or during normal operation provided that the drive has the auto reassign mode enabled.

5.1.1.5.1. Defect list report

In this mode, you can review the defect lists. You can choose to view defects for a specific head or zone. If you enable the «Summary only» option, the utility will not display the actual contents of the defect lists, instead, it will show a statistical report only.

Note: the statistical report can also be reviewed as a graphic diagram within the «Defect list editor».

5.1.1.5.2. Defect list editing

The mode allows editing of P-List, G-List, and Self Scan Defects log. First you should choose the table for editing (P-List, G-List or Defects log), and specify the copy of that table within the service area, from which its contents should be read (copy 0, copy 1 or composed reading). Then you will be prompted to specify the drive's profile or create it if it does not exist (i.e. the folder where the image file of the defect list will be placed) and then the actual file name. After that the utility reads the selected list into file and opens it in the defect list editor (in the «defects» tab). Now you can edit the defect list, all modifications will apply to the file.

«Defect list editor» is a standard component of the PC-3000 complex for Windows, it will be described in the general documentation. Here we shall mention its features peculiar for the WD utility. Right-clicking with the mouse in the window of the defect list editor opens a context-sensitive menu with a list of commands. Please find below descriptions of individual commands.

- ***Grouping to tracks*** – the command allows you to group multiple sector defects within a single track into a track defect if their number exceeds the «grouping threshold» specified after command selection.
- ***Write defects into P/G-List of the HDD*** – the command allows you to write a modified defect list back to the corresponding P- or G-List directly in the service area of the connected HDD (overwriting both copies).
- ***Sort defects*** – the command sorts all records in the «defect list editor» in the ascending order of cylinder numbers, head numbers, etc.
- ***Statistics*** – displays a graphic diagram that helps estimate the distribution of defects among heads and zones.
- ***Remove defects for head*** – the command deletes all records for the specified head. It will be described in detail in the section devoted to «Software deactivation of drive heads».

Some standard commands of the «defect list editor» also have some peculiarities.

- ***Add defect*** – the utility for WD HDD only allows you to add to a defect list records of defective physical tracks or logical defects in LBA notation. When adding a physical track, you have to specify the cylinder number and head number, then the added record will be appended to the list. When a logical defect is being added, the utility converts it into physical notation and then appends that physical sector to the list.

  Attention! Sorting is recommended after addition of defects.

- ***Edit*** – to make changes, position the mouse pointer over the target record, right-click it and use the resulting menu to select the «Edit» command. Current version of the editor supports editing of track records only. Records of physical sector defects cannot be modified because of their complicated structure.

5.1.1.5.3. Erase defect list

The mode helps clear the defect lists in a drive. Prior to beginning you will have to specify the actual list to be erased – P-List (module ID=43h) or G-List (module ID=44h). The utility performs erasure directly in the service area using both copies.

Attention! You are advised to backup P-List before erasing it.

5.1.1.5.4. Moving G-List to P-List

The mode allows you to transfer the G-List contents to P-List with subsequent resetting of G-List. It might be necessary if defects used to be hidden in a drive with the assign procedure (appending all relocated defects to G-List).

Attention! You are advised to backup P-List before transfer of defects, and run its «grouping to tracks» after the procedure.

5.1.1.6. Clear S.M.A.R.T.

The command resets the values of S.M.A.R.T. attributes in a HDD to their defaults.

5.1.2. «Tools» menu

The Tools menu offers its standard selection of features except for those, which are not available in techno mode of the HDD: «Sector edit», «View S.M.A.R.T.», «Sleep, HDD Security subsystem», «Set max LBA». If one of these features is necessary, send the Reload Microcode command or power the drive off and on again to return it to normal mode. Then you should exit the specialized Western Digital utility and launch the universal utility, which offers the required features. If you need to run the Sleep command in techno mode (e.g., for a HOT-SWAP procedure), then you can use the command from the «Utility extensions» menu.

5.1.2.1. Utility extensions

The menu allows access to the following specialized features and interactive modes:

- Modules table
- Module search in SA
- Cylinder –4 Specification
- Reload Microcode
- Self Test
- Sleep

5.1.2.1.1. Modules table

«Modules table» is an interactive mode for manipulations with the service area modules. In that mode you can view, verify, edit, overwrite modules, modify their checksums, etc. Please refer to section 6.3 for details on its use.

Warning! The mode is intended for experienced users.

5.1.2.1.2. Modules search in SA

«Module search in SA» is an interactive mode for work with the service area, which allows you to find modules that are not described in module ID=41h (modules table) and add, if necessary, the records of discovered modules to the «modules table». Selection of that mode displays an empty tab entitled «Module search in SA». If you select the «Start search [F9]» command, the utility displays a form where you should specify the search boundaries. Then the actual search process will start; it takes several minutes. After its completion, the utility displays a list of found modules, which are not included into the «modules table»:

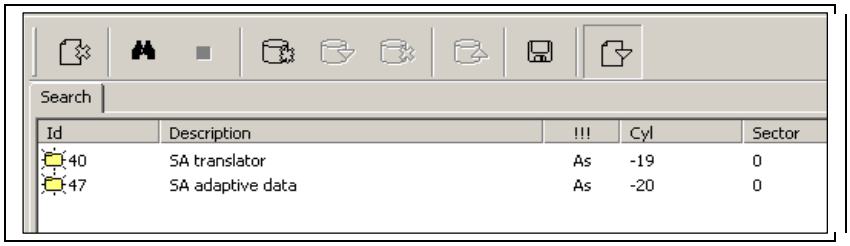


Fig. 5.4

In order to add discovered modules to the «modules table», you will have to run the «Write modules table into HDD» command adding all modules in the «Module search in SA» tab to the modules table, which will then be saved to both copies in the drive's service area (module ID=41h).

If you need to add just one module to the table, then before recording you should use the «Delete module record» command to delete all records but one and then run the «Write modules table into HDD» command.

Prior to recording, you can review module content in HEX editor. In order to do that, click the module with the mouse.

A module record can be added to the modules table using two commands: «Module record addition [Ins]» and «Module record editing [F2]». If you know module's location within the service area, you can use the information to create a module record in the modules table; then you will only have to run the «Write modules table into HDD» command.

Warning! The mode is intended for experienced users.

5.1.2.1.3. Cylinder –4 Specification

«Cylinder –4 Specification» is a visual mode in which you can review some informational tables stored within the –4 cylinder in the drive's service area:

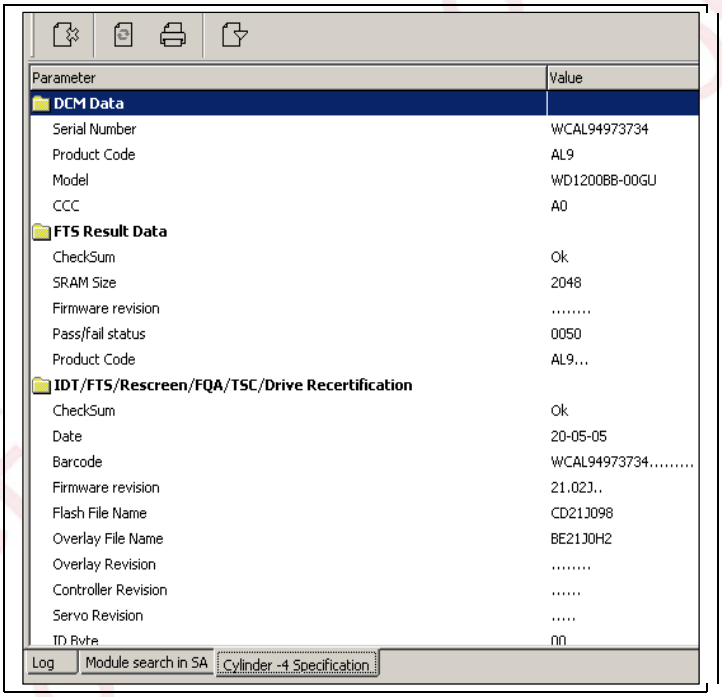


Fig. 5.5

Cylinder –4 contains a large number of various informational, service and technological tables recorded to drive during its manufacture and testing. There are over 30 such tables following each other. They do not affect the drive's operation in any way; they rather serve as a reference source with informational purpose. Let us discuss some of the most important data that can be obtained from these tables and further used for HDD restoration:

- ***DCM Data*** contains HDD serial number and model name.
- ***FTS Result Data*** contains HDD firmware version.
- ***IDT/FTS/Rescreen/FQA/TSC/Drive Recertification*** – date of factory testing, serial number, firmware version, controller version, servo data version, model name.
- ***MMS Production Log*** contains HDD serial number, model name, the number of physical heads, the number of physical zones, the number of remaining heads after deactivation of malfunctioning heads, a table of active heads remaining after disabling of malfunctioning heads.
- ***Physical Parameters Log*** contains the number of physical heads and the missing disk number.

If you need to save data from the informational tables to a file (e.g., to send it later via e-mail), run the Report command and then use the «Reports» tab, which appears next to perform the «Save report» [Ctrl]+[S]command. In order to review a received report, use the «Reports» tab in the «Tools» menu and then run the «Load from file» [Ctrl]+[O] command. Please see details in the main manuals of PC-3000 for Windows solutions.

5.1.2.1.4. Reload Microcode

«Reload Microcode» – is a command reloading HDD microprogram. Its generation makes a drive stop its spindle drive, park magnetic heads, spin up the spindle, perform recalibration and report on readiness. The feature is used to make a drive exit the techno mode.

5.1.2.1.5. Self Test

«Self Test» – is an interactive mode, which helps launch the internal drive's self-testing system seeking for surface defects and adding them to P-List, and supports its monitoring.

Selection of that mode makes the utility display an empty SelfTest tab with five controls: Launch SelfTest [F9], Launch status monitoring, Interrupt status monitoring [Esc], SelfTest termination and Display HDD status progressively. If you click the Launch Self Test icon, the utility will display a notification warning that the test will **destroy all user data**. Confirmation initiates preparations for the launch of the SelfTest procedure: the utility searches the HDD service area for the SelfTest start module (ID=E1h) and adds its record to the modules table, then it analyzes the list of SelfScan tests: Tests sequence 1 and Tests sequence 2 checking and initializing these testing modules. If some module is missing or damaged, SelfTest will not start. Successful check disables the translator module and resets log modules and defect lists. Then, in approximately a minute, the drive starts SelfTest.

While SelfTest is running, the BSY and IDX bits keep blinking in the drive status register (Display HDD status progressively mode is recommended for more convenient monitoring) and the utility displays the current test number, the number of the cylinder and the head being tested:

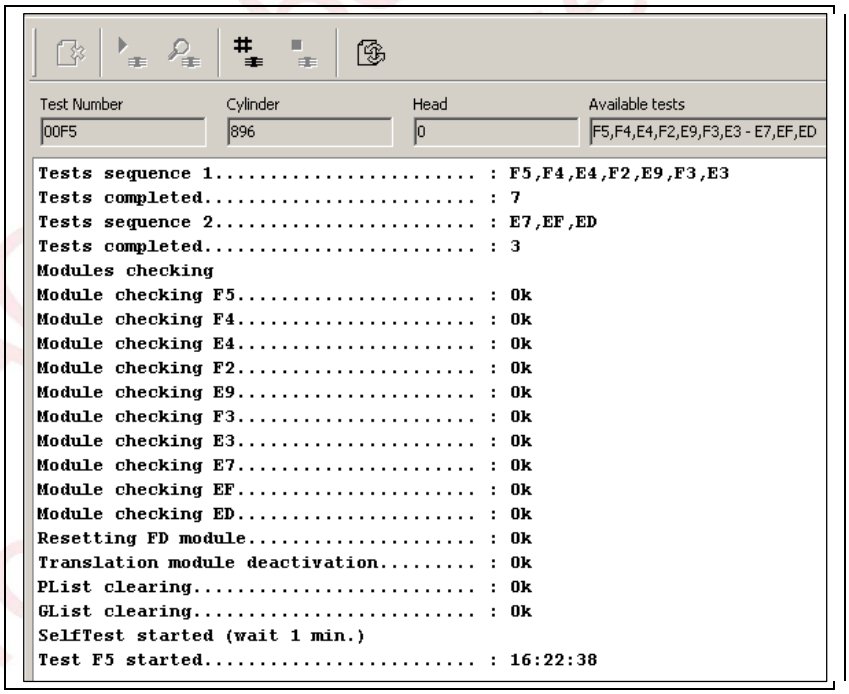


Fig. 5.6.

All tests follow each other, first the sequence 1 runs, then sequence 2. Total SelfTest duration depends upon HDD capacity and the number of defects, in general it takes 3-6 hours.

As soon as self-testing completes, the on-screen output of changing cylinder and head numbers will stop and the DRD bit in status register will be enabled.

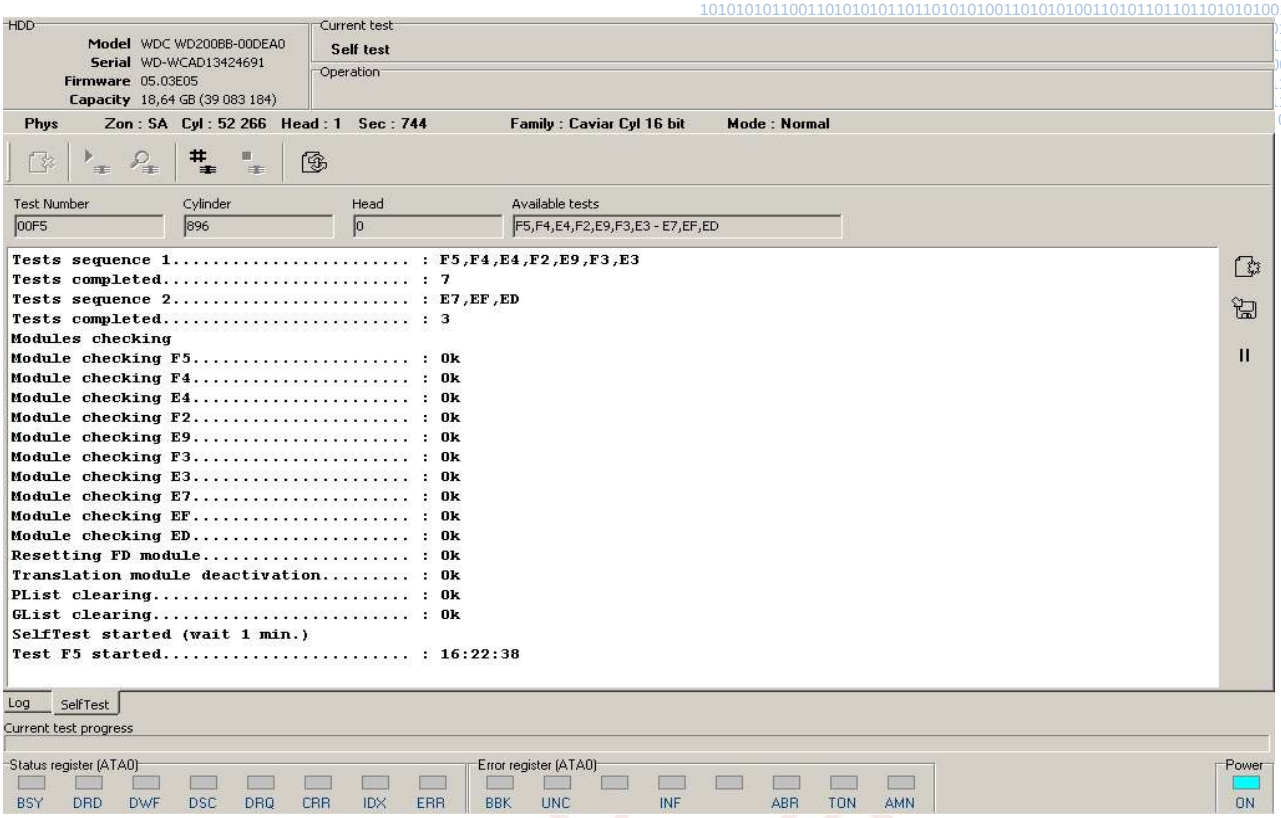


Fig. 5.7.

Then you will have to power the HDD off and on again, wait until it reports on readiness and run the «SelfTest termination» command to restore the modules modified during preparation for self-testing. Then you should run the internal formatting procedure «using P-List and G-List» (please see section 5.1.1.3).

If, while SelfTest is in progress, a critical error occurs preventing further testing, SelfTest completes and the utility displays an error code matching the **number of the test, which caused the critical failure**. In that case you will also have to power the HDD off and on again and after its report on readiness run the« SelfTest termination» command. Then you should try to analyze the cause of the failure. Perhaps, «logical test» of surfaces and relocation of defects are necessary or maybe you will even have to disable the most defective HDD side.

List of SelfTest control commands:

- ***Launch Self Test [F9]*** – the command prepares a drive to launch self-testing and starts status monitoring, which displays on-screen the test number, and the numbers of the cylinder and the head being tested.
- ***Launch status monitoring*** – the command helps resume status monitoring if it has been interrupted after SelfTest launch for some reason.
- ***Interrupt status monitoring [Esc]*** – the command interrupts cyclic polling of drive's registers and output of its status. It is necessary to stop monitoring the SelfTest progress for a given drive and leave the testing mode, for example, to connect and test another drive.
- ***SelfTest termination*** – the command can be performed only on a drive that has reported on readiness. It allows you to correct (return to normal operational condition) HDD modules and tables, which have been modified to launch self-testing. You will have to power the drive off and on again and wait until it reports ready before running this command.
- ***Display HDD status progressively*** – during drive status monitoring the utility keeps polling its registers with an interval of 200 msec, it helps avoid too high load on the CPU and possible interference with other applications including testing of another drive connected to the other port of the PC-3000 PCI tester board. The command is used in cases when you need real-time monitoring of HDD status. However, it causes processor load to reach 90-100%.

5.2. Kernel mode

The mode supports a limited number of features available for work with a HDD. It is intended for reading and writing of Flash ROM on a drive's printed circuit board separated from its HDA case. Please note that you may leave the PCB mounted on the HDA case while switching a drive into the Kernel mode. To do so, enable three jumpers simultaneously: CS, SLAVE, MASTER and power up the drive.

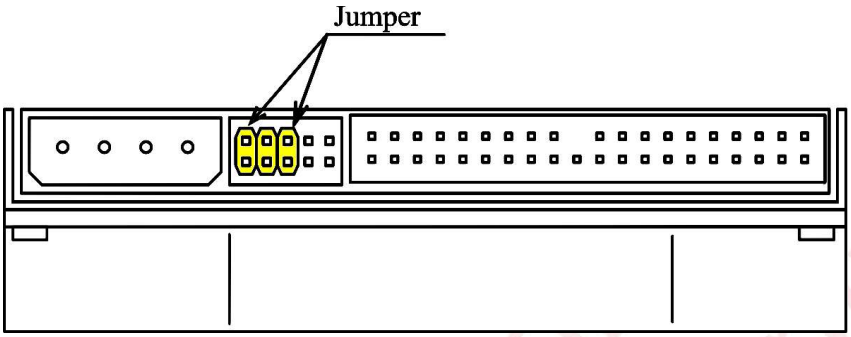


Fig. 5.8. Jumper settings for the Kernel mode

The drive at that does not process the DRD and DSC bits in the status registers, so they remain disabled. That peculiarity causes the utility to display the message shown below at the first launch; you should select affirmative response:

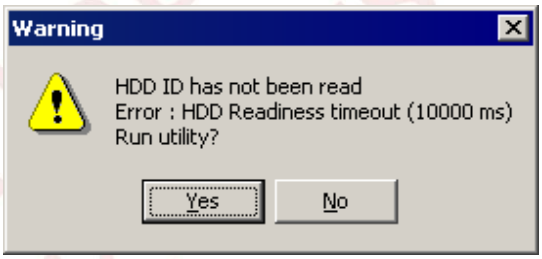


Fig. 5.9.

Then you should select the «Kernel» mode of utility operation, then «Autodetect» and «Utility start».

In «Kernel» mode the connected drive will be identified as the largest drive in the corresponding family having the highest capacity. The utility also reads ROM firmware version from the HDD in that mode. Serial number is identified as a collection of «random symbols» for WD Arch.V HDD (Caviar Cyl 16 bit) or as «PSV Mod»e for WD Arch.VI HDD *(Caviar Cyl 32 bit).*

The following features are available in the «Kernel» mode:

- View ROM information
- Head map changing
- Read ROM
- Write ROM

Operations in the «Kernel» mode are identical to similar operations in the «Normal» mode detailed in section 5.1.1.2.2 «Work with ROM»

5.3. Self test monitor mode

You may need to start the utility in the «Self test monitor» mode in case, when you start SelfTest on a drive and then run the «Interrupt status monitoring» command to disconnect the drive from its port on the PC-3000PCI tester board leaving it powered from an individual power supply so that the SelfTest routine continues.

In order to identify SelfTest completion, you should connect such drive to one of the vacant ports on the PC-3000PCI tester board (as a rule, port # 1), run the utility for the port and select the« Self test monitor» mode. The utility will then display a window prompting to select the running SelfTest instance:

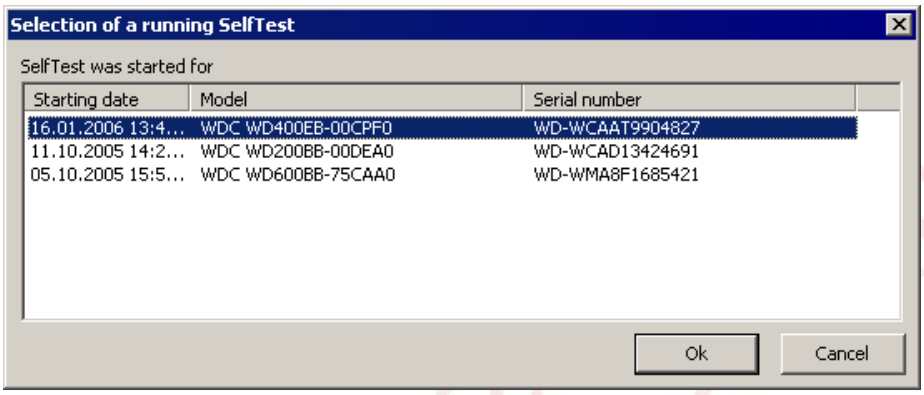


Fig.5.10.

Selection of the record corresponding to the connected drive opens a SelfTest tab containing the interrupted log for that drive. To resume monitoring, you should run the «Launch status monitoring» command making the utility start monitoring again.

While SelfTest is running, the BSY and IDX bits keep blinking in the drive status register («Display HDD status progressively» mode is recommended for more convenient monitoring). If only the DRD bit remains enabled in the status register, it means that the SelfTest procedure is over. If the ERR bit is also enabled in the status register, it indicates that SelfTest has completed with an error and the error register will contain a binary code of the test, which has caused the critical failure.

Attention! Functionality of the utility in the «Self test monitor» mode is limited. The «Launch SelfTest» and «SelfTest termination» are not available. To use these commands, you will have to restart the utility in «Normal» mode.

6. Advanced utility modes

This section is devoted to the most sophisticated modes of utility operation, which require additional explanations.

6.1. Work with service area

Service area in WD70Cxx-based (Arch-V, Arch-VI) Western Digital HDD is located within cylinders with negative numbers (from -1 to -31) and contains two identical copies of service data. Side 0 at that contains the main copy while side 1 stores the backup one. Models with single head only contain both the main and the backup copies on the same active side though they are recorded with an offset. The first copy occupies the space on cylinders -1 to -9 and the second one is located on cylinders -10 to -18; cylinders -19 and -20 contain adaptive data and the table of service area defects. The zone from cylinder -21 to -31 is empty; it is reserved for future use.

The utility provides for operations with the service area in the form of functional tests:

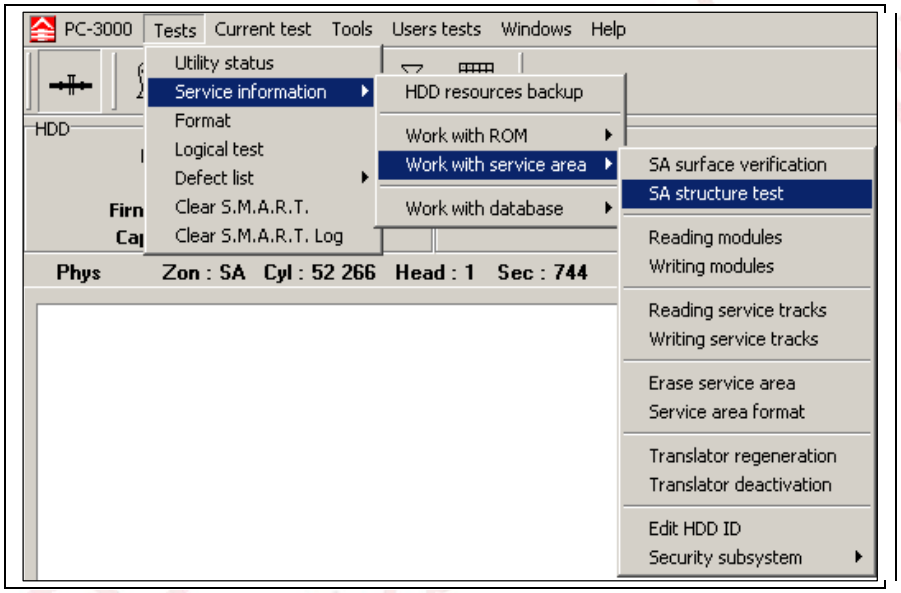


Fig.6.1.

6.1.1. SA surface verification

The utility verifies tracks in the service area making the drive read them sector-by-sector. The actual data will not be transferred to the program or analyzed in any way; instead, the utility receives just the error codes returned by the drive. You will have to specify the test boundaries prior to commencing the test. All revealed errors appear in «Log»; upon test completion they will be appended to «Report».

The main purpose of SA surface verification is detection of physical damage of magnetic surfaces (chipped parts, scratches, etc.). They can be identified by the error codes returned by the drive. Thus, errors with the INF, AMN, UNC codes are surface errors if the «Service area format» procedure fails to remove them. Errors with the UNC code are likely to be software-related, i.e. they are mostly caused by a failure while writing to the SA and not by physically damaged surfaces, so they will disappear after repeated writing.

Normal HDD functioning does not allow the presence of surface defects in both copies of service data at once. The utility does not yet support their relocation; however, on-going research of that aspect continues.

Attention! Due to some peculiarities in the work of the «Service area format» procedure cylinders -19 and -20 may contain errors even in a completely functional drive.

6.1.2. SA structure test

The command uses the «Modules table» to retrieve the addresses and read/validate all firmware modules. If the modules table does not contain a record of some module, that module will be skipped. However, the modules table usually contains records of all modules essential for HDD operation though it may lack some auxiliary modules, e.g., E1h (Self Scan start module), 47h (SA adaptive data), etc.

All reading errors revealed while testing will be displayed in the «Log». Upon testing completion the utility generates a summary «Report». Please find a sample report below.

```
SA structure test
SA MODULES LIST
-------------------------------------------------------------------------------------------
Id:Copy:Критичность:Cyl :Head:Sector:Size:Read : Hdr : CS  :  Date   : Vers.: Description
-------------------------------------------------------------------------------------------
19: 0  :     B      :  -1:   0:     2:  19:Yes : Ok  : Ok  :24-10-03:0100W : Loaded part of microprogram code
19: 1  :     B      :  -1:   1:     2:  19:Yes : Ok  : Ok  :24-10-03:0100W : Loaded part of microprogram code
1B: 0  :     B      :  -1:   0:    22:   2:Yes : Ok  : Ok  :24-10-03:0100W : Loaded part of microprogram code
1B: 1  :     B      :  -1:   1:    22:   2:Yes : Ok  : Ok  :24-10-03:0100W : Loaded part of microprogram code
1A: 0  :            :  -1:   0:    25:   4:Yes : Ok  : Ok  :24-10-03:0200? :
1A: 1  :            :  -1:   1:    25:   4:Yes : Ok  : Ok  :24-10-03:0200? :
42: 0  :     B      :  -2:   0:     0:   2:Yes : Ok  : Ok  :03-01-04:0202? : Configuration (HDD ID)
42: 1  :     B      :  -2:   1:     0:   2:Yes : Ok  : Ok  :03-01-04:0202? : Configuration (HDD ID)
43: 0  :     Dd     :  -2:   0:     3: 360:Yes : Ok  : Ok  :24-10-03:0200? : P-List (Primary defect list)
43: 1  :     Dd     :  -2:   1:     3: 360:Yes : Ok  : Ok  :24-10-03:0200? : P-List (Primary defect list)
44: 0  :     C      :  -2:   0:   364:   8:Yes : Ok  : Ok  :05-01-04:0200? : G-List (Grown defect list)
44: 1  :     C      :  -2:   1:   364:   8:No  :     :     :        :      : G-List (Grown defect list)
59: 0  :     Dr     :  -2:   0:   373:   4:Yes : Ok  : Ok  :24-10-03:0100? : T-List (Track defect list)
59: 1  :     Dr     :  -2:   1:   373:   4:Yes : Ok  : Ok  :24-10-03:0100? : T-List (Track defect list)
5A: 0  :            :  -2:   0:   378:   1:Yes : Ok  : Ok  :24-10-03:0100? :
5A: 1  :            :  -2:   1:   378:   1:Yes : Ok  : Ok  :24-10-03:0100? :
20: 0  :     Ad     :  -2:   0:   380: 144:Yes : Ok  : Ok  :01-01-98:0701? : Translator
20: 1  :     Ad     :  -2:   1:   380: 144:Yes : Ok  : Ok  :01-01-98:0701? : Translator
25: 0  :     Ad     :  -2:   0:   525:  15:No  :     :     :        :      : Translator
25: 1  :     Ad     :  -2:   1:   525:  15:Yes : Ok  :Error:01-01-98:0600? : Translator
23: 0  :     Ad     :  -2:   0:   541:   6:Yes : Ok  : Ok  :24-10-03:C807? : Translator
23: 1  :     Ad     :  -2:   1:   541:   6:Yes : Ok  : Ok  :24-10-03:C807? : Translator
4C: 0  :     As     :  -2:   0:   548:   2:Yes : Ok  : Ok  :24-10-03:0200? : Adaptive data
4C: 1  :     As     :  -2:   1:   548:   2:Yes : Ok  : Ok  :24-10-03:0200? : Adaptive data
70: 0  :            :  -2:   0:   551:   2:Yes : Ok  : Ok  :24-10-03:0200? :
70: 1  :            :  -2:   1:   551:   2:Yes : Ok  : Ok  :24-10-03:0200? :
72: 0  :            :  -2:   0:   554:   2:Yes : Ok  : Ok  :24-10-03:0200? :
72: 1  :            :  -2:   1:   554:   2:Yes : Ok  : Ok  :24-10-03:0200? :
74: 0  :            :  -2:   0:   557:   2:Yes : Ok  : Ok  :24-10-03:0200? :
74: 1  :            :  -2:   1:   557:   2:Yes : Ok  : Ok  :24-10-03:0200? :
4D: 0  :     As     :  -2:   0:   560:   2:Yes : Ok  : Ok  :24-10-03:0200? : Adaptive data
4D: 1  :     As     :  -2:   1:   560:   2:Yes : Ok  : Ok  :24-10-03:0200? : Adaptive data
71: 0  :            :  -2:   0:   563:   2:Yes : Ok  : Ok  :24-10-03:0200? :
71: 1  :            :  -2:   1:   563:   2:Yes : Ok  : Ok  :24-10-03:0200? :
```

6.1.2.1. SA modules list

This is the main report table containing summarized information about SA modules. It consists of the following fields:

- ***ID*** – module identifier.
- ***Copy*** – copy number.
- ***Importance*** – information about the importance of a given module for HDD operation or user data integrity. Modules are ranked into four groups according to their importance: **A, B, C,** and **D** arranged in the descending order:

  A – essential modules; they are individual for every drive.
  B – main modules; as a rule, they are identical in all drives within a family.
  C – additional modules of auxiliary tables; they can be simply cleared.
  D – secondary modules, which do not affect normal HDD operation; however, they are used for optional procedures, such as Selfscan, etc.

  In addition, **s, d**, and **r** characters indicate the modules pertaining to actual drive operation **(s – system)** or just to user data **(d – data)** or to service features of HDD restoration **(r – repair)**. Please see details on modules' importance in section 8.1.2.

- ***Cyl*** – number of the SA cylinder where a module is located.
- ***Head*** – number of the head corresponding to the module location.
- ***Sector*** – number of the initial module sector.
- ***Size*** – module size in sectors.
- ***Read*** – the flag indicating the result of reading all sectors of a module, it may take **Yes/No** value.
- ***Hdr*** – the flag indicating the result of module header validation, it may take **OK/Error** value. Module header is considered to be erroneous if its date is invalid or if its identifier differs from the one specified in the «Modules table».
- ***CS*** – the result of checksum calculation and verification for a module, it may take **Yes/No** value.
- ***Date*** – module date stored in its header.
- ***Vers*** – module version necessary while overwriting damaged modules.
- ***Description*** – brief description of module purpose (when known).

While reviewing the SA modules list, please pay attention to damaged modules (indicated by a different colour in the report), which should be restored. Version number of such damaged modules must be taken into account whenever you have to overwrite them.

6.1.2.2. Zone allocation table

The utility reads the zone allocation table using a special factory command of the drive; it returns the actual distribution of zones currently used in the connected HDD. You should review the table if you suspect that the translation system functions incorrectly.

6.1.2.3. Configuration sector ID=42h

The sector contains information about model name, serial number, logical parameters (LCHS and LBA) of a drive, and passwords.

6.1.2.4. DCM log, ID=C5h

The module serves as the calibrator log. The report will contain its ASCII data only, i.e. the table of DCM codes. The purpose of that table is not completely clear so far, but perhaps, in future it will allow selection of a donor drive for replacement of the magnetic-head assembly for data recovery.

6.1.2.5. Version info log, ID=4Eh

This is an overlay module loaded to HDD RAM during operation. The report will contain its ASCII data about firmware versions only. It will be most significant for Arch.VI (Caviar Cyl 32 bit) WD drives because their serial Flash ROM contains no such data. The information is useful for selection of a compatible electronics board.

6.1.2.6. P-List, G-List defect list

The report contains just the number of defects in these tables.

Attention! «DCM» and «Version info» data in C5h and 4Eh modules are optional as they are generated in logs. Thus, their absence or garbage in their place do not indicate SA or HDD damage.

6.1.3. Reading modules

The command uses the «modules table» to obtain the locations and read user-defined firmware modules. If the modules table does not contain a record of some module, that module will be skipped. However, the modules table usually contains records of all modules essential for HDD operation though it may lack some auxiliary modules, e.g., E1h (Self Scan start module), 47h (SA adaptive data), etc.

Before the «Reading modules» procedure you should specify the destination for the modules (profile folder or database), select identifiers of the modules for reading (if you wish to read just the specified modules) and define the reading method («Copy 0», «Copy 1» or «Composite reading»).

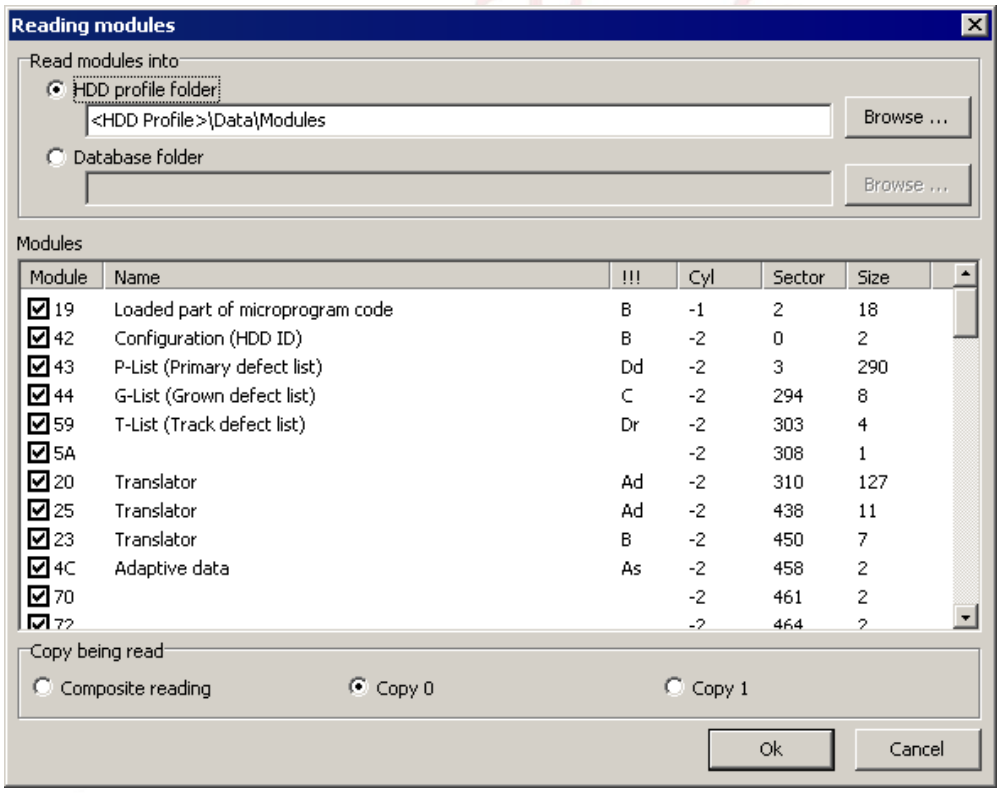


Fig.6.2.

Filenames for every read file will be generated as follows: ~IDxx.rpm, where xx stands for module identifier, e.g.: ~ID42.rpm is the configuration module.

6.1.3.1. Reading from copies

The reading mode in the utility provides for an opportunity to select the source firmware copy. In a completely functional drive both firmware copies are identical (please see section 6.1). However, if a head gets damaged you can switch the copies and read successfully the necessary firmware modules. If a drive fails to read a certain sector of a module, such module will not be recorded to the resulting file.

6.1.3.2. Composite reading

Composite reading is intended for reading of firmware zone elements (modules, tracks) in cases when both SA copies are damaged. When that mode is selected, reading starts using the copy specified during the previous step. However, if later reading that copy encounters an error, the reading routine will switch the copy automatically and attempt to read the same sector from the other copy. If it succeeds, reading continues using the same copy further until the next error, which again causes copy swap and so on until the whole reading procedure is complete. The algorithm is very efficient for recovery of firmware data when different parts of SA copies are damaged. If the utility encounters errors reading one and the same sector in both copies, it will not write such module to the resulting file.

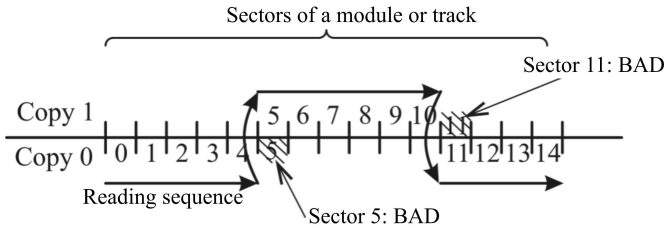


Fig.6.3. Composite reading principle

6.1.4. Writing modules

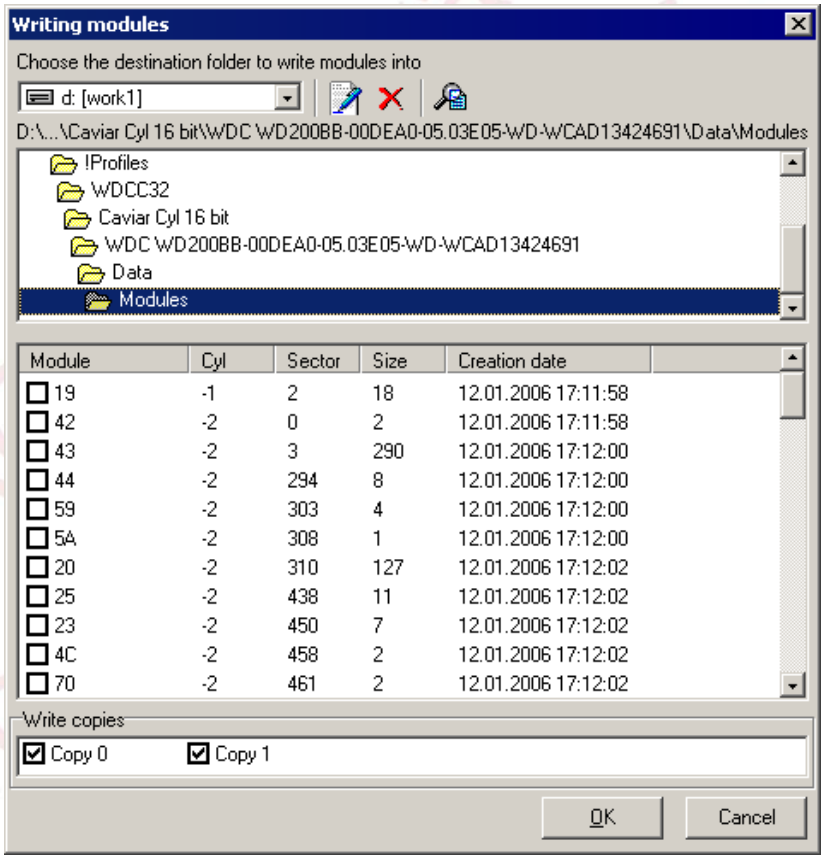


Fig.6.4.

Recording of modules is performed in strict conformity to the «Modules table», if the latter lacks a record of a module, such module cannot be written to the service area. The peculiarity follows from the fact that the modules table contains complete information about the location of modules while actual modules contain no such data. Therefore, if a module has to be added to the service area, first you should add its record to the «Modules table ~Dir».

If you are writing a standard module (present in the table), you should select the source of module files, i.e. Profile «folder» or «Database». Use the window, which appears next to select the necessary modules and specify the copies that should be overwritten. In most cases modules have to be overwritten in both copies.

6.1.5. Reading service tracks

As we have demonstrated above, the modules directory does not contain descriptions of all modules present within the service area. Therefore, reading modules from their table does not allow reading (and subsequent recording) of all SA modules. Thus the utility offers a separate mode for work with the service area tracks.

Similarly to modules' reading, the procedure of tracks reading requires that you first specify the destination for read tracks: a «Profile folder» or «Database». Then you should mark the tracks and heads to be used for reading. If the service area is seriously corrupted, you should select «Composite reading» (please see section 6.1.3.2).

Filenames for every read track are generated as follows: xxxx_yy.trk, where xxxx stands for the track number combined with the minus sign, yy is the number of the head used to read the track. If the value is "ff", it means that the track was recovered using composite reading. If a certain sector within a track cannot be read, for example, because of an error, the utility will write to the resulting track file a sector consisting of 256 Word type records with DEADh code.

Together with every read track the utility creates a file with an identical name and the .map extension containing the reading map of that track. The number of bits it the file corresponds to the number of sectors in the track. If a sector has been read successfully then the utility adds 1 to the map file, if an error has occurred while reading it, the added value will be 0. The sole exception is the last byte, which may contain 0 because the number of sectors per track may be not divisible by 8. Such mechanism allows you to analyze corruption of tracks and take actions necessary to recover or compose damaged SA tracks, especially modules essential for drive operation or user data.

6.1.6. Writing service tracks

The command writes previously read tracks to the drive's service area. Prior to recording, you should select the source of track files: «Profile folder» or «Database». Use the window, which appears next to select the necessary tracks and the heads to be used for track recording. If you select «Track filename-based head ID», recording will be performed using the same heads, which have been used to read the respective tracks. The feature will not be available for tracks recovered by composite reading; in that case you will have to specify the head explicitly.

6.1.7. Erase service area

This command writes plain codes to all SA sectors thus erasing all the data stored in the service area. Prior to running that command, you should specify the boundaries for erasing, numbers of the heads and the code to use as the fill-in pattern: AAh, 55h, FFh or 00h.

Attention! This is a factory mode and therefore it cannot be recommended for novice users.

Warning! Performance of this command renders a HDD inoperable after it is powered-off or reset.

6.1.8. Service area format

This command formats tracks from -1 through -18 of the service area using heads 0 and 1, and regenerates the table of SA defects and the table of adaptive data for SA, which are recorded then to tracks -19 and -20. Due to that peculiarity in the operation of the format command, tracks -19 and -20 may contain unformatted portions causing reading errors, which in this case may be ignored as irrelevant.

Formatting erases all service information. Therefore, prior to actual format the utility performs «Composite reading» of tracks -1 to -18 and writes them back after recording. If you configure the utility using the «Do not save HDD resources (format only)» option, then it will not read and then write the tracks back.

Attention! This is a factory mode and therefore it cannot be recommended for novice users.

Warning! Running this command «without saving HDD resources» renders a drive inoperable after it is powered-off or reset.

6.1.9. Translator regeneration

This command forces the drive to «regenerate translator», create and write to the service area modules 20h (pdlist) and 25h (rbblist). P-List and G-List tables serve as the source of original data:

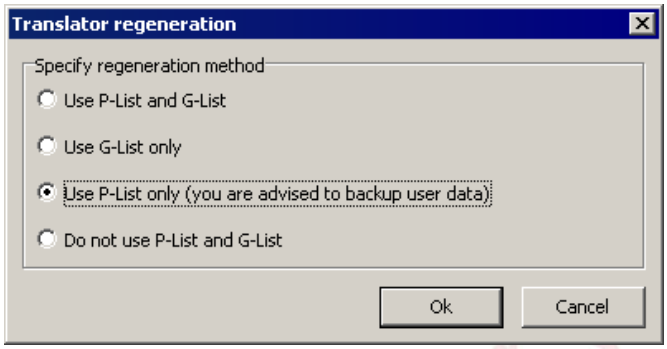


Fig.6.5.

During production at the manufacturing factory all defective sectors are revealed and added to P-List first, then translator regeneration and format taking into P-List follow. G-List at that remains empty. During drive operation all user data are placed on drive sides in accordance with the translator generated at the factory and newly revealed defects are added to G-List only. Therefore in cases, when a drive's translator (modules 20h and 25h) is damaged, restoration of access to user data requires translator regeneration in the «Use P-List only» mode.

6.1.10. Edit HDD ID

Selection of that mode brings up a form, which allows editing of logical parameters of a HDD:

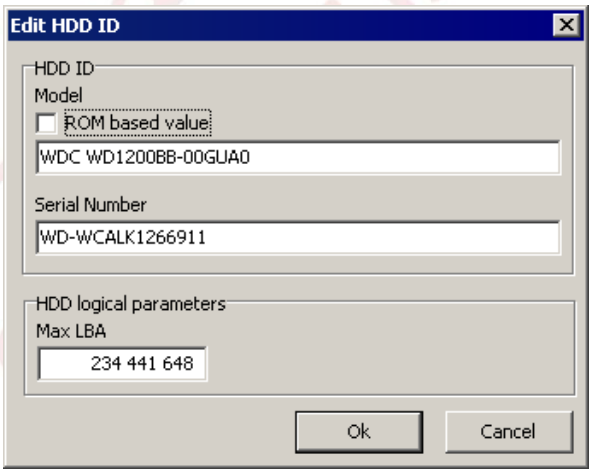


Fig.6.6.

All these parameters are returned by a drive in response to the «HDD ID (ECh)» command. If you enable the « ROM based value» checkbox, the model name will be selected by the drive from a table in Flash ROM depending upon the number of heads in that model. The modifiable value stored in the service area will be ignored then.

For WD Arch.V (Caviar Cyl 16 bit) the utility outputs the LCHS value instead of the Max LBA value:

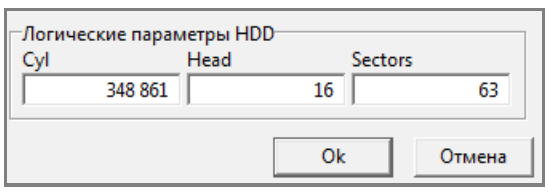


Fig.6.7.

Max LBA in that case can be calculated by multiplying the values of Cyl, Head, and Sectors fields. Reverse conversion from LBA to LCHS (for example, if you wish to decrease available logical space because of multiple defects in the end of the disk) requires maximum LBA value where errors still do not occur divided by 1008 (the product of logical heads and sectors) – use the integer part of the resulting value as the number of logical cylinders.

Warning! If an erroneously specified Max LBA or LCHS value exceeds the volume of available physical space and then it is accidentally used for translator regeneration or formatting (which also regenerates the translator) the drive will start endless knocking hitting its heads against the limiting stop (please consult section 8.3 for details).

6.1.11. Security subsystem

Commands available from this menu item allow reviewing or resetting of passwords in a HDD.

6.1.11.1. View password information

The command displays a report on enabled passwords and actual «Master Password» and «User Password», if they are set.

6.1.11.2. Clearing passwords

This command erases all passwords set in a drive irrespectively of their security level – «High» or «Maximum».

6.2. Logical test

The most important parameters of any surface scan are its «duration» and «reliability» of detection of defective sectors and those sectors, which are likely to become defective in future. These are contradictory parameters and a trade-off between them is difficult to reach. Therefore, in this version of the utility developers decided to discontinue physical scanning of surfaces, and a separate test of servo labels using instead logical scanning only. It has also been decided to sacrifice an insignificant portion of normal disk space to achieve higher testing rate.

While testing WD drives for defective sectors and tracks, the utility uses multi-sector logical scanning of user area in LBA notation instead of physical scanning via PCHS (as it has been implemented in some other utilities). In fact, logical test performs a multi-sector surface verification (the ATA 41h command with sector counter set to 256) without actual data transfer via the interface. Although the logical scanning mode allows reading test with support for writing of various test codes to HDD surfaces and reading them after that, you are advised to avoid such tests during the first pass to increase the test speed. These are also not recommended for the whole HDD disk surface; instead, they should be used on a limited space portion for its more thorough testing, if necessary.

6.2.1. Peculiarities of logical surface scanning

The first peculiarity of logical test using multi-sector verification is manifested in the fact that the utility sends to HDD verification commands for sequences of 256 sectors and, if an error occurs within such range, the program has to identify the exact LBA of the area causing that error. In order to accomplish that, the same area has to be rescanned in sector-by-sector mode.

The second peculiarity is represented by absence of protection against the possibility of drive hanging in case when a track with corrupted servo labels is encountered. As a rule, a drive in that case processes received command (verification, writing or reading) for a very long time for each LBA within the damaged area and after all the waiting it returns an error: IDNF, AMNF or Time Out. There may be multiple damaged sectors following each other within a whole track or even several tracks. With the modern recording density a track consists of approximately 1000 sectors, so it is quite easy to estimate the time necessary for testing a single track with a damaged servo label if the drive will return a Time Out error after 10 seconds for each sector.

Therefore the logical test procedure employs various methods to avoid seriously damaged defective areas and hide them as track defects. The first method is to skip a defective spot using a specified number of LBA, which should not be less than the length of a single track or several tracks – and to continue surface scanning. The whole skipped area will be hidden as a track defect(s). The second method is based on reduction of Time Out error response time to 200 msec or even less. That will allow you to avoid losing much time expecting a HDD to reach readiness in case of serious errors.

6.2.2. Implementation of the logical test procedure in the utility

The actual logical test procedure and its settings do not differ from the scanning procedure provided for in the universal utility (see the universal utility description), but we should discuss in detail its use as applied to the testing of WD drives.

When you launch the logical test procedure, the utility opens the «Logical scan parameters» screen form. As we have mentioned before, you are advised to use «Verify» only from the set of available test as it will save considerably the time necessary for testing. Set the number of passes to 1, it will be sufficient for most cases. Then switch to the «Additional» tab.

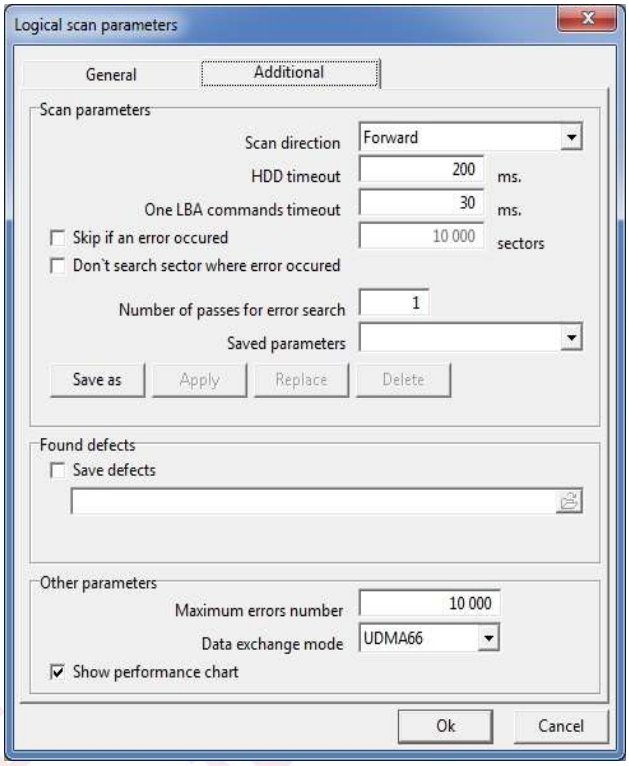


Fig.6.8.

- You are advised to select ***Forward*** as the «Scan direction» (in the ascending LBA order).
- ***HDD timeout*** is an essential parameter. It determines the time the utility will wait after command until HDD reaches readiness. If HDD «timeout» is exceeded the «Response to HDD timeout error» sequence of actions will be applied to the drive (please see section 6.4 devoted to utility settings), command execution at that will be interrupted and a «HDD Readiness timeout» error will be generated. The utility will proceed to the next command.

  The average time it takes a drive to perform a multi-sector verification command for 256 sectors (provided there are no errors) does note exceed 30 ms, that is why the default «HDD timeout» is 200 ms. However, sometimes analysis of error codes returned by the drive itself requires to wait until the HDD reports ready. In that case you will have to increase «HDD timeout» to 5 – 10 sec.
- ***Skip xxxx sectors if an error occurred.*** If the option is enabled, then in case of a surface error the utility will skip the number of LBA specified in the data field of that parameter and proceed testing surface in the reverse direction until the first error encountered. Then it will add all sectors between these two errors to a defect list. We do not recommend setting the number of skipped sectors to less than 1000 (average statistical number of sectors per physical track of a modern drive).
- ***Don't search sector where error occurred.*** If the option is enabled, then a surface error detected revealed by multi-sector verification (writing or reading) the utility will not search for a specific defective LBA within the 256-sector range; instead, it will add all 256 sectors of the range to the defect list.

Attention, important note! We should describe separately a situation when both of the «Skip xxxx sectors if an error occurred» and «Don't search sector where error occurred» options are enabled or disabled:

1) Both options disabled:

Detection of an error during multi-sector verification (writing or reading) triggers search for a specific defective LBA within the 256-sector range, its value will be added to the defect list and the utility will proceed with further scanning. In case, when multi-sector verification of a 256-sector range reveals an error but a sector-by-sector range scanning does not detect the error, nothing will be added to the defect list.

2) Both options enabled:

If during logical scanning multi-sector verification (writing or reading) reveals an error, the utility will not search the 256-sector range for a specific defective LBA; instead, it will skip the number of LBA specified in the option data field and proceed with forward surface testing. It will, however, add to the defect list all sectors beginning with the start of the defective 256-sector range until the end of the area equal to the skipped surface portion. If after the jump the utility detects an error in the new 256-sector range, it will skip it again and add to the defect list twice the number of sectors specified for skipping, etc.

6.2.3. Practical application of logical test

Depending upon the condition of HDD surfaces (presence of damaged servo labels), the number of already hidden defects (i.e. the remaining reserved capacity), logical scanning should use different combinations of its configuration options: «Skip xxxx sectors if an error occurred and Don't search sector where error occurred».

The following settings are recommended for most cases of surface testing of WD drives:

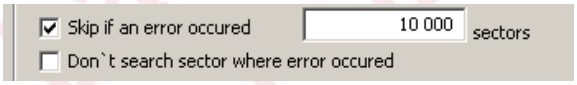


Fig.6.9.

Such configuration provides for optimal ratio between speed and testing quality while using the reserved HDD space efficiently.

If you need to test surfaces with multiple damaged areas really fast, you are advised to enable both parameters. The number of skipped sectors in that case can be set to a value within 1000 - 2000.

If you need to test every sector and add to the defect list only actually detected errors, both configuration options should be disabled. Testing in that case takes maximum time. However, sometimes it does not detect errors that appear irregularly.

6.2.4. Hiding defects after a logical test

Upon completion of the logical surface test procedure the utility displays the following dialog:

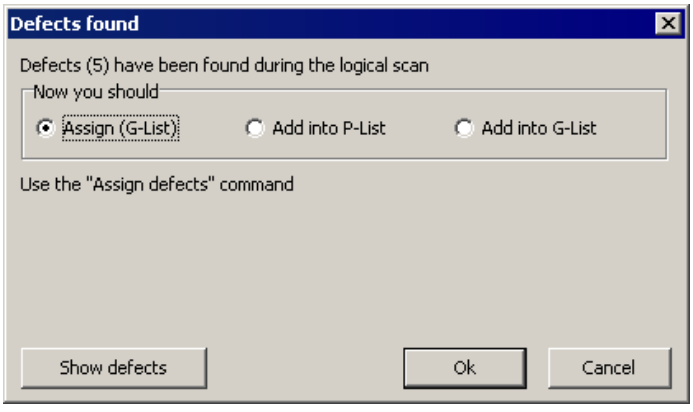


Fig.6.10.

The upper line shows the number of found continuous defective area. Each such defective area may contain a single sector or several thousands of sectors. In order to review the revealed defects, click the *Show defects* button, which will open the following table:

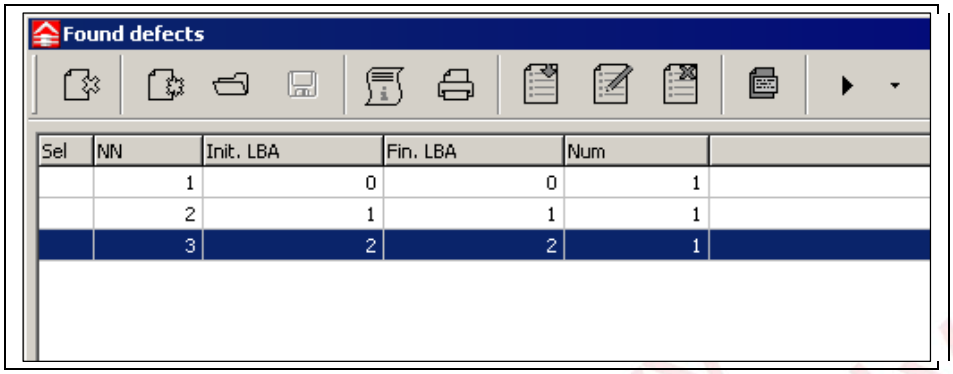


Fig.6.11.

The lower line of the table displays the number of defective areas and defective sectors. After review, you are advised to close the table and return to the «Defects found» dialog. Use it to select the method, which the utility should employ to hide the defects: «Assign (G-List)», «Add into P-List» or «Add into G-List».

If you select Assign as the relocation mode for every defective sector, the utility initiates a similarly named procedure provided for in the ATA specification. Then the WD drive will process every defective sector, enable the defective indicator in its identification field, specify the reserved sector number and correct accordingly modules in the service area: RBB List, Event Log, G-List and SectMap. Defective sectors become inaccessible immediately after that relocation method is used. One drawback of that method is the number of the sectors, which can be hidden using Assign and limited to 500 – 800. Besides, the method cannot hide sectors damaged in the identification field (IDNF and AMNF errors), and sectors close to a corrupt servo label. Operation of a HDD with sectors hidden using the Assign method is somewhat slower because of repositioning to the reserved area.

Selection of defects' addition to P-List or G-List makes the utility first read the defects list of a drive into a file. Then it converts all newly discovered logical defects into physical notation and adds them into that read defect list (it can request to specify a profile to save the list file). In that table you can perform standard manipulations of defect editing (if necessary), but in this case you will most likely need just two of them: «Grouping to tracks» or «Write defects into P or G-List» of the HDD. The latter option appears depending upon your earlier choice («Add into P-List» or «Add into G-List») and performs actual recording to the selected defect list within the SA of the HDD.

Attention, important note! We should also mention the system that performs conversion of logical defects into physical ones and automatic grouping into tracks. After a logical test (irrespectively of its configuration parameters) the utility identifies single logical defects and their continuous areas (e.g., after jumping over skipped surface parts). All single defects are converted into physical ones using the command for LBA to PCHS transfer. If a continuous area contains less than 1000 logical defects, they will also be converted into physical sectors using the same command. If a continuous logical range contains more than 1000 sectors, then only the first and the last LBA defect from that range will be converted. They will be converted into physical tracks and then the utility will add to the defect lists all tracks for all heads between those cylinders.

Finally, after recording of defects into P or G-List you should run the internal formatting procedure taking into account the defect lists to actually hide the. The method proves to be most efficient while hiding all kinds of surface defects. As soon as the translator is regenerated and formatting is over, the drive will not access the areas listed in P- and (or) G-List. It will seem to ignore them. That is the method used to hide defects at the manufacturer's factories.

6.3. Modules table

The mode will be described in the next revision of this document.

Attention! The mode is rather sophisticated and therefore it cannot be recommended for novice users.

6.4. Utility settings

These settings include general configuration of the complex as well as utility-specific parameters pertaining to the *Caviar Cyl32* utility.

«HDD timeout» and «Sound» settings are parameters of the PC-3000 complex for Windows relevant for work with WD drives. By default, the utility uses a 10 sec «Timeout», but it may be insufficient for drives with damaged service area. Such drives may need more than 2 minutes to reach readiness, so that work with them may require increasing the «Timeout».

Sound settings allow you to specify a melody to play upon completion of long procedures, for example, after formatting or logical scanning. That will help attract attention to the drive being restored.

Attention! If you modify the «Timeout» duration for testing of malfunctioning drives, remember to restore the original value later.

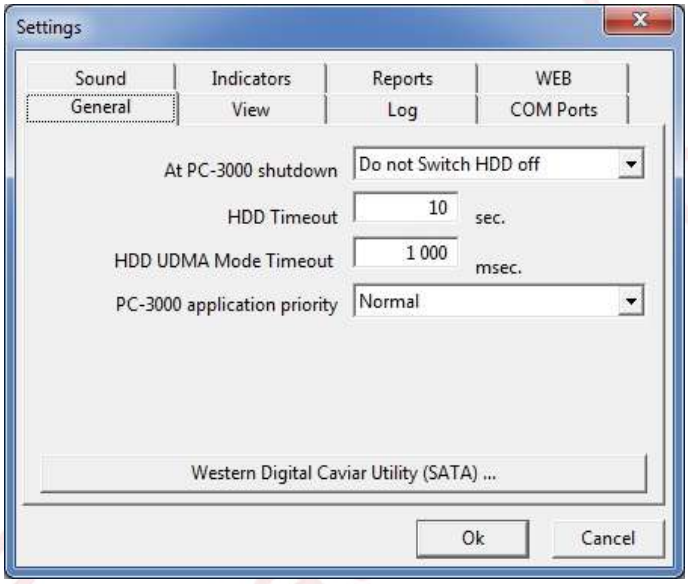


Fig.6.12.

Utility-specific settings can be accessed using the *Western Digital Caviar Utility...* button

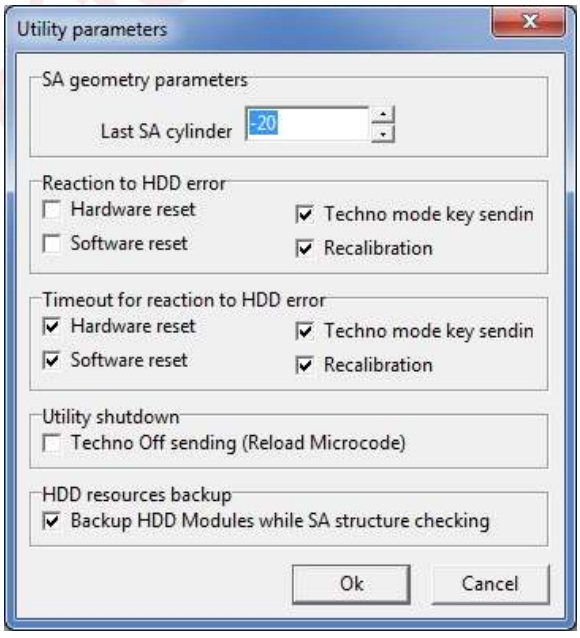


Fig.6.131.

The window allows you to define service area parameters – «Last SA cylinder» and the «Reading command» used to access sectors in SA as well as utility-wide parameters – «Reaction to HDD error», and actions at «Utility shutdown».

The «Last SA cylinder» value restricts in the input editor the boundary cylinder used in all manipulations with the SA. The service area physically starts with cylinder -1 and continues to cylinder -32, although actual service data is stored between cylinders -1 through -20. The area from cylinder -21 to -32 is not formatted; therefore the default «Last SA cylinder» value is -20. Please note, that in some cases, for example, during manual testing of heads' functioning, you can use the range to «Erase service area» or perform «SA surface verification».

The «Reading command» field value allows you to specify a command to use for reading of service area sectors: «20h (With hardware retries)» in case of an error or «21h (Without retries)». The selected command will be used for all SA reading operations. You can try changing it if the SA reads poorly in order to obtain the best possible results.

«Reaction to HDD error» and «Timeout for reaction to HDD error» options allow you to configure the drive's behaviour in case of an error. The utility interacts with a drive in techno mode and an error may result in a hanging drive or even cause it to exit the techno mode.

If you need to start the *Universal utility* while working with a drive, then you should first make it exit the techno mode, otherwise subsequent work in the universal utility will be incorrect. The «Utility shutdown» parameter allows you to send the Reload Microcode command upon exit from the specialized utility. You can also simply power the drive off and on to make it exit the techno mode.

The utility offers implemented logical scanning for detection of surface defects. Therefore the window also provides access to «Logical scan parameters», which allow setting the «Reaction to HDD error» while scanning the surfaces using logical parameters.

Attention! The utility interacts with a drive in techno mode; therefore remember to switch the drive to user mode of operation when exiting the utility.

Warning! Specialized settings of the utility are optimal for beginning to medium level specialists. Modification of these settings can only be recommended to highly skilled engineers who clearly understand the consequences of such actions.

7. Diagnostics of malfunctions

Precise diagnostics of malfunctions ensures 50% of success in HDD repair. That is why diagnostics of a drive sent for restoration should be performed extremely carefully, preferably without opening the HDA or overwriting the service data modules. During diagnostics you should attempt to minimize the risk of even greater damage to the drive or user data. If data have to be retrieved from a drive with damaged service area or data area, then you should also minimize whatever operations of recording into that HDD.

A hard disk drive is a sophisticated «hardware and software device» and the same manifestations of a malfunction sign may be caused by physically damaged hardware (mechanical or electronic) components or a purely software failure (damaged service modules or microprogram in ROM). Besides, a drive consists of two main parts – head-and-disk assembly case and the electronic board. Therefore it is necessary, when possible, to use replacement with a known good component to check whether the problem is in the HDA or the board.

HDD malfunctions can be subdivided into the following groups:

- Damaged spindle motor controller chip
- Damaged voltage generators
- Damaged microprogram in ROM
- Non-native PCB or microprogram.

HDA malfunctions:

- Damaged spindle motor (bearing seizure, breakage or short-circuit of motor phases)
- Damage to one or more heads
- Damaged preamplifier-commutator chip

- Surface scratch and damaged head
- BAD sectors
- Reading/writing instabilities
- Corrupted firmware
- Incompatible firmware modules overwritten by a third party.

When a drive arrives for repair or data recovery it is essential to ask the client about what had happened to the HDD and what they did with it after the malfunction appeared. Did they take it to another company for repair or did they bring it straight to you? Quite frequently such information may assist you in determining the direction of malfunction search.

7.1. Initial diagnostics

Diagnostics should start with an external inspection of the HDA and the PCB. In order to do that, you should remove the PCB from the drive. If the board exhibits no visibly damaged components and the HDA does not rattle, it is time to try to power it on.

It is better to perform the first test power-on using an individual power supply unit with the interface cable disconnected. If after power-up the spindle motor spins up and you do not hear the positioner knocking against the limiting stop, then the drive can be connected to the PC-3000 complex for Windows. If a drive keeps knocking with its heads, there is little hope for its easy restoration and in some cases it may even prove impossible. Some methods of restoration for knocking drives are described in section 8.3.

Before you connect the drive to the PC-3000 complex for Windows, you should disable or set to inactive positions all the HDD configuration jumpers. Then you should identify the architecture used in the drive: WD70Cxx or Marvel 88i554x, the type of Flash ROM used in it – parallel or serial (to do that, you will have to remove the PCB) and launch the corresponding utility.

During diagnostics it is essential to identify precisely the malfunctions, which can be fixed using software feature of this complex and damage, which cannot be repaired with software methods only.

7.2. Electronics board

Normal functioning of the PCB can be tested most reliably if you connect it to a known good HDA from an identical drive. In order to ensure complete compatibility, you will have to write to the Flash ROM of the PCB being tested the firmware from the native board of the HDA used for test (please remember to backup the original firmware). Sometimes it is also possible to just solder the Flash ROM chip from a board of a known good HDA to the PCB being tested. If a drive with a known good HDA and a tested PCB functions without errors, then the problem is not in the controller board. Then you should write back the original firmware (or return the ROM chip) and proceed to searching for HDA defects. However, if the PCB does not function on a normal HDA and acts in the same manner (identical to its connection to the malfunctioning HDD being tested) then it is the source of problems and you should try to find the malfunction and eliminate it. Data recovery does not require PCB repair; instead, you should just install to the "patient" HDA a known good board (having recorded to its Flash ROM firmware from the patient's PCB or having soldered its ROM chip onto the normal PCB) and copy user data.

Cases when both the PCB and the HDA of a drive become damaged are very rare. They may occur only when the power supply unit of the host computer becomes damaged and the supply voltage of +5V or +12V lines is exceeded drastically. In such cases, as a rule, all PCB electronic components and the preamplifier-commutator chip in the HDA become damaged. Another possible variant is intentional replacement of a functional PCB on a malfunctioning HDA by a third person; it should be kept in mind.

Spindle motor controller chip failure is a typical cause of PCB malfunctions. The chip at that frequently gets physically damaged:

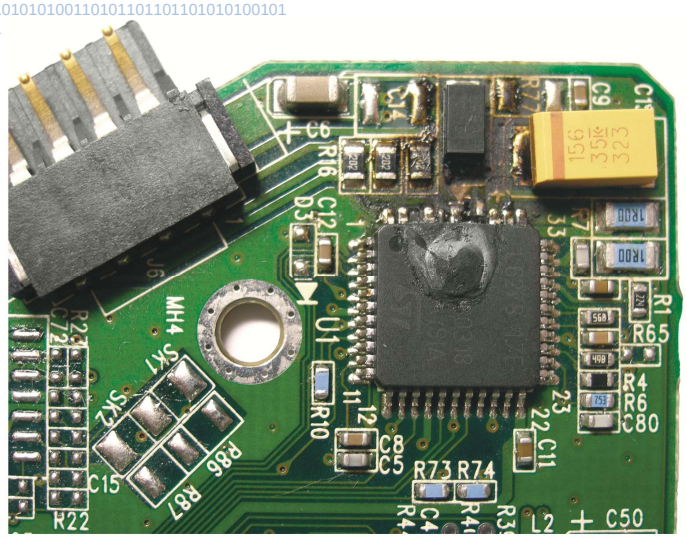


Fig.7.1. Damaged spindle motor controller chip.

In that cases auxiliary components (diodes, voltage-reference diodes, current-limiting resistors) also frequently become damaged.

Sometimes a PCB has no visibly damaged parts but the drive does not start to spin up the spindle motor. In such cases you should remove the board from its HDA, connect it to an individual power source and check first the supply voltages including those generated by the board; then check the operation of the quartz oscillator and the activity on the data and address bus of the microprocessor. Then switch the board into the *Kernel* mode and check its operation in that mode, i.e. reporting on readiness, reading of identification parameters, ROM reading.

The spindle may also fail to start spinning up because of a damaged preamplifier-commutator chip. You can check this assumption by placing a strip of heavyweight paper between the PCB contacts and the MHA connector on the HDA case. If doing so will allow the spindle motor to start, it means that the chip inside HDA is damaged.

Some methods applicable for PCB diagnostics and repair are described in section 1.1.

7.3. Head-and-disk assembly

If you have checked the PCB and determined that the problem is in the HDA, then you should proceed to the diagnostics of the latter. If you do not need to recover data but wish to repair the drive, then opening the HDA case is prohibited even if all clean room requirements are observed. The consequences of such actions may be really destructive for further operation of a modern drive:

- A used drive is covered by dust, which penetrates under the HDA case up to the sealant, and it is extremely difficult to remove it completely. As soon as you open the case cover, the remaining dust gets inside the HDA.
- Spindle motor shaft and the positioner's shaft are mounted to the HDA case cover and after that servo labels are recorded to platters. Even simple opening and closing the cover introduces microshifts in the mutual alignment of these shafts. During operation these shifts may cause the drive to overwrite the edges of servo labels.

We can definitely state that a drive, which requires opening its HDA for repair, cannot be restored so that it later functions with guaranteed reliability for a long time. Such malfunctions include:

- Damaged spindle motor (bearing seizure, breakage or short-circuit of motor phases)
- Damaged preamplifier-commutator chip
- Surface scratch.

7.3.1. Spindel motor malfunctions

In order to check a spindle motor, you will need to measure the resistance of its coils, which should be ~ 1 - 2 Ohm.

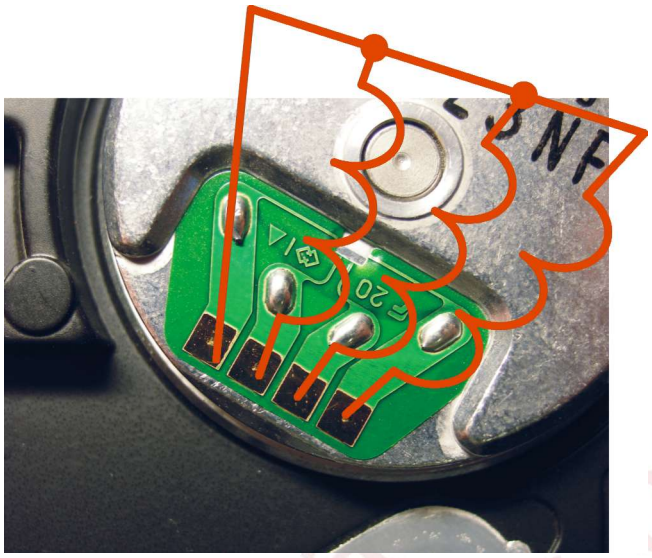


Fig.7.2. Photograph of a motor indicated with phases.

7.3.2. Malfunctions of drive heads and preamplifier-commutator

It is rather difficult to detect and even more difficult to identify the faulty component precisely when you have to decide between the reading element of the head or a channel of the preamplifier-commutator corresponding to it.

WD drive families include models using 1 to 6 heads. The sequence of heads' placement within an assembly (if no heads have been deactivated) corresponds to earlier generations of WD drives:

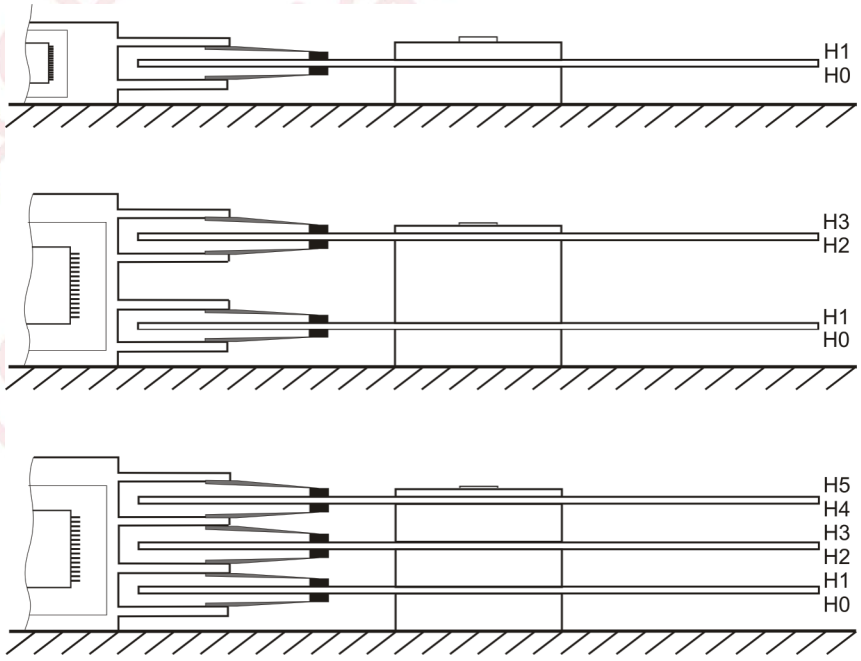


Fig.7.3. Heads arrangement in 2-head model, 4-head model, and 6-head model

However, there may be exceptions. E.g. a 4-head drive may use heads on its lower and middle disks without the top disk installed, or a single-head drive may use a head located on top or under the lower disk. As a rule, a drive with disabled heads contains their location reflected in the head map (please see section 5.1.1.2.2.).

If the reading head element or its corresponding channel on the preamplifier-commutator is out of order, then selection of that head interrupts the stream of servo data, the stabilization and positioning system can no longer adjust the head to a track, the whole magnetic-head assembly moves sideways to the limiting stop and hits it. Then it bounces, moves again and hits the stop once more. The process may continue for quite long time. If you hear that the heads are knocking during diagnostics, you should disable the drive's power because every hit damages the HDD heads and surfaces.

In order to identify the damaged and normal heads you can inspect them sequentially one after another checking, which of them cause knocking. During that procedure you do not have to wait until the drive reaches readiness as the presence/absence of knocking sounds is essential here. The drive at that must be switched to the *Kernel* mode. Use the head map to disable all heads but one, then install the PCB onto its HDA (remove the *Kernel* mode jumpers) and switch on the power supply. If the drive starts knocking after the spindle motor spins up, it means that the head is damaged. If a drive keeps knocking with every head, then, perhaps, the preamplifier-commutator itself is damaged.

7.3.3. Defects of magnetic surfaces

If a HDD with a functional PCB spins up the disks, unparks the heads but produces slight knocking at an attempt to recalibrate, then such behaviour may be caused by a notch on the platters. Diagnostics of such malfunction definitely requires opening the HDA and careful visual examination of the magnetic surface mirror and the air filter, which may contain dislocated microparticles of the magnetic layer.

You can also perform partial scratch diagnostics by looking at the zero side through the STW pushpin opening.

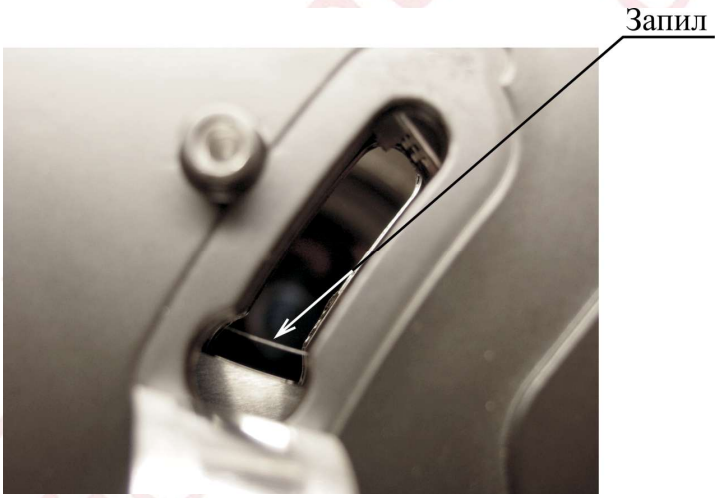


Fig.7.4. Запил на поверхности магнитного диска.

You should pay attention to disk edge and the parking area. These are two locations, which are most prone to scratches because they are so close to the limiting stops of the positioner, which drive heads may hit and then bounce back scratching rotating disks and their magnetic layers; removed particles of the latter, in turn, again cause dislocation of new particles whenever they fall under a moving head, etc. Once a notch appears on one side it will very quickly spread all the others.

If a notch is present on disk surface, it is impossible to restore the complete functionality of a HDD or recover data from it.

8. Software restoration

Software restoration can be subdivided into several steps:

- Restoration of damaged SA functionality (surface test of the service area, verification of the SA structure, overwriting or restoration of damaged service modules).
- Testing of user area surfaces and relocation of revealed defects (logical test, additions into the defect list and formatting).
- Modification of HDD configuration, deactivation of malfunctioning heads (decreasing Max LBA, editing the head map).

- Adjustment of adaptive parameters, detection and relocation of defects using the internal scanning procedures (Calibrator, Self Test).

As a rule, in order to gain access to user data on a damaged HDD, it is sufficient to restore the functionality of the service area only. Then you can copy necessary data. In case, when there are defects on the HDD surfaces, the necessary data can also be read, though Data Extractor has to be used due to its numerous modes of data recovery.

Therefore the procedure of HDD in cases, when you need just the data, will be as follows:

1) ***Restore the service information.*** During the procedure you should strictly observe the rules of restoring firmware modules essential for user data.
2) ***Perform selective surface verification*** of the user data area (usually in the beginning, middle and the end). Make sure that the service area has been restored correctly and you have access to data throughout the whole drive surface. If BAD sectors are detected, estimate their number, locations and error codes. That will help you determine the opportunities for data recovery and the time it will take.
3) If there are no BAD sectors in user data area, copy required data using whatever available means. Otherwise use Data Extractor to recover the data.

In order to restore HDD functionality completely and use the drive later (provided that all user data will be lost), the following procedure should be used: Восстановить служебную информацию.

1) ***Restore the service information.***
2) ***Clear G-List, reset SMART, clear logs.*** If you disable some heads, remove their records from the P-List table. If you decrease Max LBA, remove the P-List records, which may be outside the resulting logical space. If, during SA restoration, you have overwritten P-List with a copy from another drive, it should be cleared.
3) ***Perform formatting using P-LIST;*** the procedure must complete successfully. If formatting completes with an error, it may mean the presence of corrupted servo labels on certain surfaces. You can try perform grouping into tracks (track defects block access to corrupted servo labels) or disable the side containing too many defects.
4) ***Perform search for defects and hide all revealed ones.*** Use Logical test or SelfTest ***to*** accomplish that purpose.
5) ***Use the results of test 3 and 4 to make a conclusion regarding the need for grouping into tracks, disabling of certain sides or a decrease of MAX LBA.*** If you have performed these procedures, you should proceed with the restoration from step 2.
6) ***Perform formatting using P- and G-List.***
7) ***Correct the model name and serial number*** in HDD ID, if necessary.
8) ***Run a complex test*** in the universal PC-3000 for Windows utility making sure that there are no errors and the drive functions normally.

8.1. Service area testing and restoration

In case, when a drive spins up the spindle for a very long time (over a minute), does not report ready, then reaches readiness but keeps responding with ABRT errors to any command or reads its HDD ID incorrectly or identifies itself by its factory alias, then service data corruption is very likely.

Despite the presence of two copies of firmware data, corruption of service modules because of failures is a very frequent problem in WD HDD. It occurs because a drive working constantly with some SA modules keeps reading, editing and recording them, for example modules with SMART values, translator modules during the auto reassign procedure, log modules, etc. Whenever writing to the SA occurs, a drive overwrites both copies and a recording failure damages both of them. As a rule, a writing error damages CRC fields resulting in errors while reading modules. The data within modules also become damaged, then a mismatch of module checksum may occur; sometimes module

headers are damaged, too. In all these cases no actual damage occurs to the surface of magnetic disks and the corruption of service modules is clearly expressed: there are a few damaged editable modules (in both copies at once).

In other cases disk surface may also get damaged (a scratch, notch, etc.), for instance, because of a head that has accidentally touched it. In that situation corruption of modules may look irregular and a drive often continues to function normally reading the service information from a backup copy.

The heads may also become damaged, then an attempt to read service information using a malfunctioning head will result in multiple errors.

8.1.1. Service area testing

The utility offers two modes for SA testing: automatic and interactive mode. Automatic mode can be invoked from the menu: «Tests» → «Service information» → «Work with service area» → «SA surface verification and SA structure test» (please see section 6.1). Interactive mode can be accessed from the menu: «Tools» → «Utility extensions» → «Modules table», but it is not so easy compared with the automatic mode, so it cannot be recommended for novice users (work in that mode is described in detail in section 6.3).

After «SA structure test» the utility will display a «Report», which will contain a summary table of «SA MODULES LIST», i.e. the list of all tested modules. You should check, which modules are damaged in both copies, because they are the objects that should be restored.

8.1.2. Service area restoration

In order to restore corrupted modules, you have to identify the type of each module and its importance for the drive and for user's data. The summary report table indicates the importance for each module as a code:

As – unique modules essential for HDD operation. These include adaptive data. In case of their corruption HDD restoration will be impossible or it will be very difficult. If a WD HDD has such damaged modules, then you should try to read their original contents from copies or use composite reading and only in the worst case you can try overwriting them with copies from an identical HDD model of the same drive family (perhaps, you will have to pick them from various identical HDD). A drive at that may suffer from impaired reading or recording functionality or even start knocking.

Ad – unique modules essential for user data. This list includes translator modules. If they become corrupted, a HDD can be repaired, but all user data will be lost. If a WD HDD has such damaged modules, then in order to preserve user's data you should attempt restoring them by repeated reading of their original tables. These modules cannot be copied from another drive, as it will result in the loss of user data. However, the method might be acceptable if you do not need the data and wish to repair the drive only.

B – working modules of loadable firmware portions, various tables (zone allocation, HDD ID, etc.). They are not peculiar for every drive although they are individual for a drive family or even a specific model within it. If they become corrupted, it is sufficient to copy them from an identical model of the same family; sometimes you have to take firmware version into account.

C – tables of secondary importance, such as SMART, G-List, etc. Their restoration is often provided for in the drive itself through special mechanisms. Thus, for instance, to restore SMART tables you just have to reset the attributes of SMART values. It is also allowed to copy these modules from another drive (preferably belonging to the same family and model). That does not affect HDD operation and the integrity of user data.

Dd – auxiliary modules, which do not affect HDD operation and the integrity of user data but still participate in the procedure of restoration of other essential modules. E.g., the original translator table (it can be used to restore a corrupted translator).

Dr – auxiliary modules, which are not used in normal HDD operation. However, they play their role when a drive performs maintenance functions, such as the SelfTest or Calibrator procedures.

As we have demonstrated above, editable modules become corrupted most frequently. Let us examine some methods of their restoration.

8.1.2.1. Restoring module ID=44h (G-List)

The module is not critical for a HDD or user data. Therefore, its restoration requires that you simply clear it. The task can be accomplished from the «Defect list» → «Erase defect list» → «G-List». If the module's header is damaged, you should first copy it from any drive of the same family and then clear it.

8.1.2.2. Restoring module ID=21h (Event Log)

This module is not critical for HDD operation or user data, so its restoration also requires just copying it from another drive of the same family.

8.1.2.3. Restoring modules ID=26h, 29h - 2Fh, (S.M.A.R.T.)

All these modules belong to the SMART system of a HDD and therefore they are not critical for its operation or user data. Thus, if any SMART module (26h, 29h, 2Ah, 2Bh, 2Ch, 2Eh, 2Dh, 2Fh) gets corrupted you only have to «Clear S.M.A.R.T.» If some of SMART modules remain corrupted, then you should first overwrite them with copies from any other drive of the same family and then «Clear S.M.A.R.T.»

8.1.2.4. Restoring modules ID=20h, 25h (Транслятор)

These are the main translator modules, which are unique for every WD drive. That is why they cannot be copied from another HDD. If they are damaged, the utility suggests restoring them with a recalculation of the original translator tables, i.e. P-List and G-List. In order to preserve user data the regeneration procedure should use P-List only. It can be started from the menu «Service information» → «Work with service area» → «Translator regeneration».

8.1.2.5. Restoring modules ID=22h, 23h (Транслятор)

These modules contain no unique data although they belong to translator as well. Their version is an essential compatibility parameter. If they get corrupted, it will be sufficient to copy them from another model of the same family, but the module version must match. Thus, for example, completely identical models of the same drive family with the same firmware version may use various versions of modules 22h, 23h, which will be incompatible.

8.1.2.6. Restoring module ID=43h (P-List)

The module itself does not affect HDD operation of the integrity of user data, but in case of translator corruption it will be necessary for its correct regeneration and restoration of access to data. The utility offers two methods for its recovery. The first approach is based on an attempt to assemble the P-List module from copies provided that its structure is known. The second method uses SelfTest log. The first technique is rather complicated, the procedure must be performed manually but it case of a success it guarantees complete restoration of the native P-List. The second method is automatic, but it guarantees restoration of native P-List only in 50% of all cases.

Attention! We should note here that due to some peculiarities in the organization of the translation system in WD drives beginning with Arch-I and through Arch-VI, only native P-List (used to regenerate translator at the manufacturing factory) can guarantee access to user data when the translator gets damaged. Even slightest modification in P-List (addition or removal of some record) will make recovery of user data impossible. Please refer for details to the section devoted to the WD translation system.

The first method is based on the fact that module ID=43h containing the P-List table is rather large and it can occupy 300 – 400 sectors while the actual P-List may take far less space. As a result, the corrupted portions of module 43h may be located after P-List leaving the table intact. However, module checksum applies to the whole module from beginning to end and its reading is considered successful only if the utility reads it from the initial sector to the final one without errors. That is why a message informing about an error while reading module or its corrupted checksum may leave chances of extraction of a whole functional P-List. In order to check that opportunity you should use the «Tools» → «Utility extensions» → «Modules table» interactive tool (please see section 6.3). Then you should find module ID=43h (P-List) in the list of modules and use the mouse to double-click it. The utility will then read the module and open a new View tab, which is actually a hex editor window containing the selected module. In the module selection mode («Modules» tab) you can toggle the copy used for manipulations or enable composite reading with the «Select SA copy» toolbar button. It will allow you to read module 43h and load it into the hex editor with the least damage. Use the hex editor to identify sectors, which are damaged for whatever reason. E.g., sectors, which could not be read, will be marked as DEAD (256 word DEADh). Sectors, which were read but still contain damaged data structures, are harder to identify (such sectors cause module CRC errors); however, that is still possible. Damaged module structures are distinctly visible in the empty part of the P-List table. The empty area must contain of zeroes only, so if any sector contains data other than 00, we should conclude that the sector is damaged. If damaged parts of module 43h do not touch P-List, use the «As defect list» command in the hex editor «Plugins».

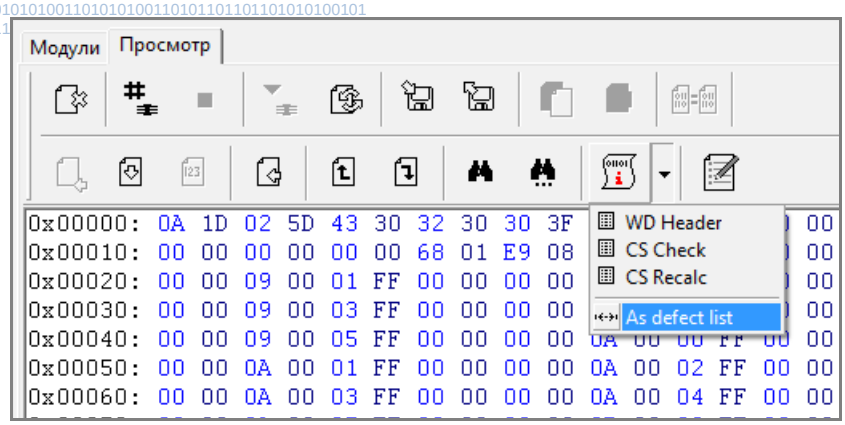


Fig.8.1.

Prior to that you should select the range occupied by P-List from the module beginning until the table end. If the corrupted part of module 43h is within P-List, then even composite reading will not allow complete restoration of P-List (and, therefore, of the translator), although it can be restored up to the corrupted part. That will help gain access to a part of user data, which may be sufficient to copy necessary data. As soon as you run the «As defect list» command the selected P-List range will be copied to the defect list editor; then you can use the «Write defects into P-List of the HDD» command to restore module ID=43h (P-List).

The second method of P-List recovery is based on the analysis of SelfScan log stored in module ID=FFh. At the manufacturing factory, all defects revealed by the SelfScan procedure are added to the log with subsequent generation of P-List on its basis during one of the last tests. Thus, if P-List becomes damaged you can try restoring it using the SelfScan log. There is a special mode provided in the utility for that purpose: «Defect list» → «Defect list editing» → «Defects Log», in that case the defect list from log will be copied to the defect list editor and then you can run the «Write defects into P-List of the HDD» to restore module ID=43h (P-List). Unfortunately, the real P-List of a drive does not always exactly match the defect list generated from SelfTest log. Probably, an additional surface testing is performed at the factory after SelfTest and P-List generation, and then revealed defects, if found, are also added to P-List, which is only then used to regenerate the translator. That is why this method proves helpful in approximately 50% cases.

Attention! Both methods overwrite the native P-List, but you should start from the first method as it ensures higher reliability and only if it fails should you proceed to the second method of P-List recovery. Please keep in mind that only the native P-List will be able to return user data in case of translator corruption.

8.1.3. General guidelines for service area restoration

Certain modules within the service area are unique both for the operation of the drive and for user data. Therefore you should backup all resources of a HDD before you start working with it, namely: Flash ROM contents, service modules and service area tracks (use the «Service information» → «HDD resources reserving» menu to that effect). Their availability will allow a roll-back in future if some recovery actions prove to be erroneous.

During restoration of corrupted modules overwrite just the damaged ones. Never overwrite the service area completely (all service tracks or all modules) with a copy from another drive.

If you feel uncertain about the methods selected for restoration of specific damaged modules, use the Save report feature to save the report generated by SA structure test and send it to a more experienced individual or to the ACE Technical Support at pc-3000support@acelab.ru

Tip! You are advised to install to your computer «Report viewers for the PC-3000 complex for Windows» offered for free. Then you will be able to review a report easily whenever you receive a message with an attached report.

8.2. Software deactivation of drive heads

The need to disable certain heads appears when they become damaged or in case of damaged side that a head is using. In any case the malfunction manifests itself as a large number of defective sectors and tracks for the corresponding head.

In order to disable malfunctioning heads, select the Head map changing command (please see section 5.1.1.2.2). Select «From map» as the value in the «Heads configuration» field and uncheck the heads to be disabled in «Head map».

«Heads number» is an essential parameter, which defines the maximum number of heads for that MHA type; it may take 6, 4 or 2 as its value.

Attention! If a HDD previously used «Default» heads distribution and then it becomes replaced with the «From map» flag, then the «Heads number», «The number of heads in use» values turn out to be 0 and all heads are disabled. Then you should specify the «Heads number = 6, 4 or 2» (as the highest value supported in the family) and enable the supposed heads (e.g., 0 and 1 in a 2-head model). If the drive after that starts knocking, it means that the heads have been enabled incorrectly and you should try selecting two other heads, for example, «1 and 2» or «2 and 3». Alternatively, you can enable the heads one by one and thus identify all connected and functional ones. Please keep in mind, that there are models with a missing middle platter in the package, in that case «Head map» may be «0, 1, 4, 5» with «Heads number = 6».

Upon completion of «Head map changing» the generated map will be recorded to Flash ROM of the drive.

8.2.1. Head disabling procedure

If have tested a drive and discovered that a certain head must be disabled, proceed as follows:

- Disable the translator. If you do not do that, then after head deactivation the translator may contain leftover records pointing to that disabled head, which are certain to cause drive hanging or knocking. To disable the translator, set to zero the checksum byte in modules ID=20h and ID=25h (please see section 6.3).
- Use the mode provided for modification of head map in Flash ROM of the drive and disable the malfunctioning head. You can select the «Default» configuration of heads or the «From map» option at that.

If the «From map» configuration of heads is selected in a HDD, then:

1) Select Work with ROM - Head map changing, From map distribution.

2) Uncheck the box of the head, which must be disabled.

3) Enter Defect list editor (P-List), select Remove defects for head and remove from the defect list all records pertaining to the head being disabled. If you are removing defects for a head in the middle of MHA, then the Move remaining heads option must be enabled. Doing so will shift one head lower all records for the heads placed above the one being disabled.

Note: A HDD uses during operation a continuous head map unlike the physical one present in its ROM. Therefore, please be careful deleting defect records from P-List and make no mistake about the head number which may differ from the physical head number.

4) Clear G-List.

5) Use the Work with service area - Edit HDD ID menu to correct the Max LBA or Max Cyl value.

Note: In drive ID of WD Arch.V (Caviar Cyl 16 bit) HDD you can edit the number of logical cylinders while in WD Arch.VI (Caviar Cyl 32 bit) HDD you have to correct the Max LBA value. The new Max LBA or the number of logical cylinders can be calculated as follows:

The old Max LBA (or Cyl) value must be **divided by** the old number of heads and **multiplied by** the new number of heads. Then **deduct** from the resulting figure 100000 LBA (or 100 Cyl), necessary for reserved space, which in that case will amount to approximately 50 Mb. Reserved capacity can be smaller or larger depending upon the number of defects on the remaining surfaces.

6) Perform internal formatting using P-List.

7) Run a logical test and hide all revealed defects (please see section 6.2.).

A situation is possible, when a HDD previously used «Default» heads distribution and then it becomes replaced with the «From map» flag, then the «Heads number», «The number of heads in use» values turn out to be 0 and all heads are disabled. Then you have to identify (pick) these values using model name and drive family code as guidelines. Another prompt is in the fact that drives using «Default» heads configuration may not have disabled heads while the number of heads in use is generally divisible by two – 2, 4 or 6, i.e. it is determined by the used MHA type. Here are several examples:

Example 1. MDL: WD800BB-00CAA1, capacity 80 Gb - it is a WD Arch.V (Caviar Cyl 16 bit) HDD.

Switch the PCB into «Kernel» mode and launch the utility, which identifies the model (WDC WD800BB), and the number of heads (Head Count: 4). Then perform «ROM data reading» to see on-screen the list of supported models:

WDC WD200BB
WDC WD400BB
WDC WD600BB
WDC WD800BB
WDC WD1000BB
WDC WD1200BB

Based on the highest WD1200BB model and its capacity of 120 Gb, we can identify that the drive uses a 4-head MHA with probable (presumably) map 0, 1, 2, 3.

Example 2. MDL: WD1200JB-00CRA1, capacity 120 Gb – it is a WD Arch.V (Caviar Cyl 16 bit) HDD.

Switch the PCB into «Kerne»l mode and launch the utility, which identifies the model (WDC WD1200BB), and the number of heads (Head Count: 6). Then perform «ROM data reading» to see on-screen the list of supported models:

WDC WD200BB
WDC WD400BB
WDC WD600BB
WDC WD800BB
WDC WD1000BB
WDC WD1200BB

Based on that data, you can determine that the HDD uses a 6-head MHA with (probable) map 0, 1, 2, 3, 4, 5.

Example 3. MDL: WD800BB-75FRA0, capacity 80 Gb – it is a WD Arch.VI (Caviar Cyl 32 bit) HDD.

Switch the PCB into Kernel» mode and launch the utility, which identifies the model (WDC WD2400LB), and the number of heads (Head Count: 6). HDD using Serial ROM do not contain a list of supported models, so you may skip «ROM data reading». Instead, you can try to proceed from the highest model WD2400LB with the capacity of 240 Gb and 6 heads – then this drive can use a 2-head MHA with probable (presumably) map 0, 1.

After you determine the head map used in a drive, you can continue disabling heads according to the above-described method applicable with HDD with heads configured «From map».

Attention! If a drive starts knocking after head map modification, then disabling has been performed incorrectly. Then you should switch the PCB to «Kernel» mode and write back the original ROM firmware (used prior to map modifications). Always save a backup copy of native firmware before editing the map.

Attention! If after head disabling you regenerate the translator or perform formatting (which also regenerates the translator), but accidentally forget to correct the logical space accordingly (decreasing Max LBA or Max Cyl), then the drive will start knocking at the next power-up. In that case you should initialize the drive without firmware loading (please refer to section 8.3.) and as soon as the HDD reaches readiness, overwrite to it its previously saved module ID=25h. After that you should modify the logical parameters as necessary and regenerate the translator.

8.3. Restoration of a knocking drive

If after power-up a drive spins-up the platters and keeps knocking its heads against the limiting stop, it means that the servo adjustment system does not receive the servo signal from heads.

- If knocking is caused by a burnt-out preamplifier-commutator or a surface scratch, then **software restoration of such drive is impossible.**
- If one or several heads are damaged, HDD functionality can be restored with a loss of capacity by means of their software deactivation (please see section 5.1.1.2.2.). However, that method is not acceptable for user data recovery. The latter will require replacement of a functional MHA from a donor drive.
- A situation is also possible, when after the spindle motor spins up, the drive begins recalibration but starts knocking, discontinues spinning the motor, then starts it again and resumes the process. Such malfunction can occur when an accidentally set Max LBA or LCHS value exceeds the size of available logical space if that value has been used to regenerate the translator. For example, it may happen during heads deactivation if you forget to decrease the logical disk space accordingly.

- Another possible situation may occur when an incompatible module or modules get written into the service area of a drive. As a result, the drive hangs during initialization, it does not report ready and does not allow recording back saved normal modules.

In these two latter cases you can restore HDD functionality rewriting to it correct firmware modules. However, the drive should report ready for that purpose, but it does not achieve that stage. The problem can be solved using several methods:

1) You can use old and reliable HOT-SWAP technique (please see section 8.4.).

2) You can employ another method preventing the stream of data returned while reading RDx, RDy by a short-circuit of checkpoints E19 and E26 on the PCB:

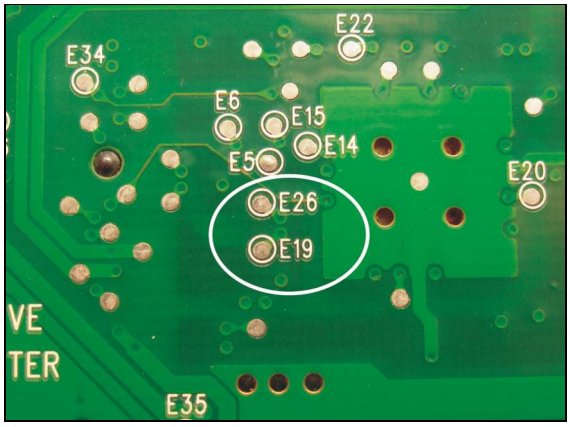


Fig.8.2. HDD WD ArchV (Caviar Cyl 16 bit) checkpoints

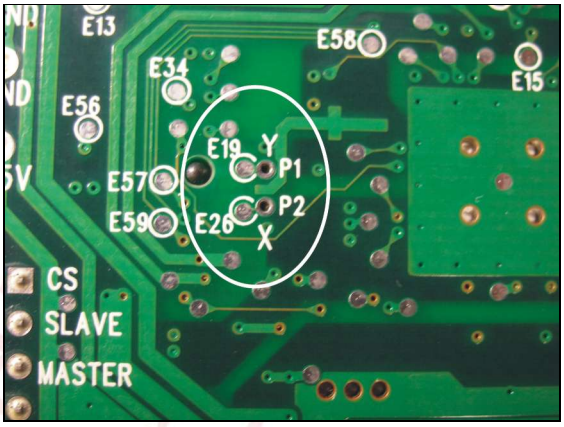


Fig.8.3. HDD WD ArchVI (Caviar Cyl 32 bit) checkpoints

To use this method, start PC-3000 for Windows, but do not start the utility. While the «Utility selection» window is on-screen, use tweezers to short-circuit checkpoints E19 and E26 on the PCB and power up the drive. Doing so must light up the BSY LED on the virtual «Status register» panel; the drive will spin up the spindle and begin knocking with the positioner against the limiting stop. In approximately 30-60 seconds the BSY LED will go off and DRD and DSC LEDs will light up, then you should remove the tweezers. The drive will report on readiness without reading the firmware modules in RAM, which is actually necessary. Start the utility after that (you might have to select the «HDD family» manually), validate corrupted modules and overwrite them, if necessary.

The method cannot be recommended as the best because it causes the drive to knock with its heads against the limiting stop. That may damage heads and disks (please see the section «Defects of magnetic surfaces»).

3) There is an alternative method, which unfortunately only works with WD Arch.V (Caviar Cyl 16 bit) HDD using the WDC 50G6474 IBMBM 1.1 (U7) reading channel chip. Similarly to the previous case, the method is based on interference with the data stream, which should occur after the servo data signal necessary for heads adjustment to track is already received. The said data stream passes checkpoint E30, which should be short-circuited to «ground»:

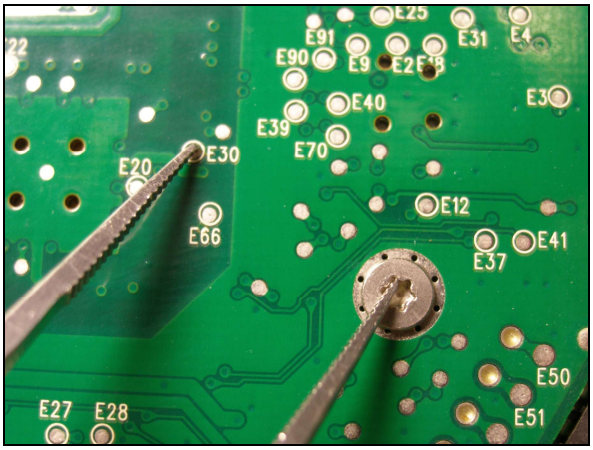


Fig.8.4. Short circuit of HDD WD ArchV (Caviar Cyl 16 bit) checkpoint

The procedure necessary to use the method is completely identical to the previous case. The only difference is manifested in the fact that a drive with checkpoint E30 short-circuited to «ground» does not knock with its heads.

The method is very useful, but it does not work with WD Arch-VI (Caviar Cyl 32 bit) drives built on the Marvell 88C5540-LFE[1] (U7) reading channel chip. In these HDD, the servo data signal is singled out after checksum E30 (directly in WD70C22 system controller), so its short-circuit will result in head knocking.

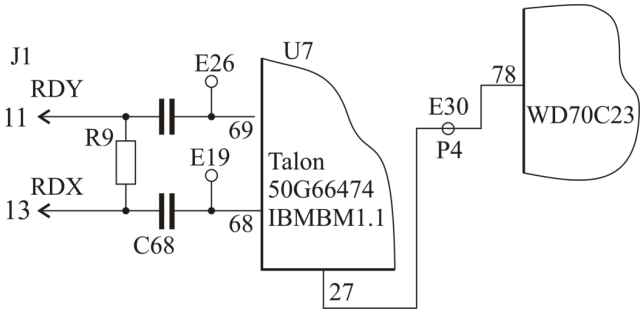


Fig.8.2. HDD WD ArchV (Caviar Cyl 16 bit) checkpoints

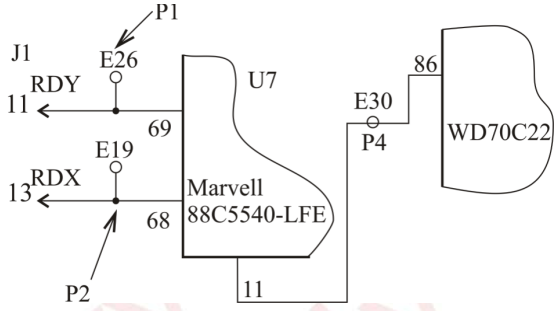


Fig.8.3. HDD WD ArchVI (Caviar Cyl 32 bit) checkpoints

4) There is another universal method suitable for HDD using both architectures. It employs interference with the data stream passing checkpoint E26 by its connection to the «ground» through a filter. As such filter, you can use the probe supplied for unlocking of HITACHI-IBM AVV2 and VLAT drives (please see the description for HITACHI-IBM drives). The filter passes the servo data signal at the same time distorting the read data signal. The procedure necessary to use the method is completely identical to two previous cases. A drive will not knock with its heads after a connection of checkpoint E26 to the «ground» through the filter.

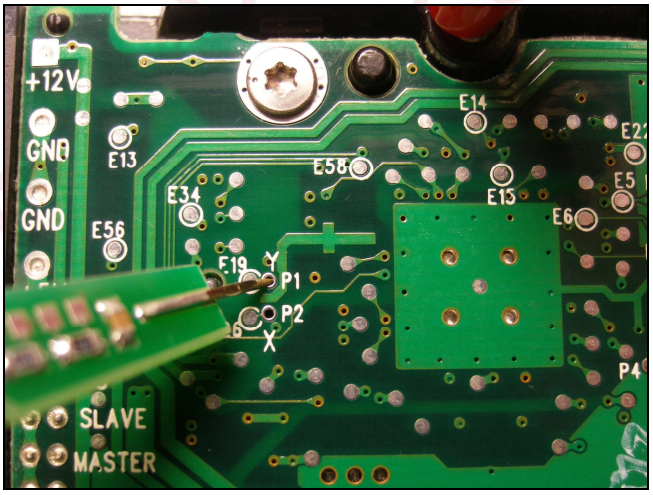


Fig.8.7. Connecting the HDD WD ArchVI (Caviar Cyl 32 bit)checkpoint to the ground via a probe.

The method is the best among other approaches listed in this section, so it is recommended for use. However, it may fail in some cases, for example, because of different bandwidth used in various models.

8.4. HOT-SWAP method

The method is universal for testing and attempts of data recovery from various drives. It is used when service data is damaged and there is no way to check it using built-in means of the drive, for example, because it hangs. There are certain limitations for HOT-SWAP use with any drive. They exist fro Western Digital HDD as well:

[1] - These should not be confused with the architecture of HDD based on Marvell 88i554x system controller.

- WD HDDs are sensitive to firmware version. HOT-SWAP is impossible if the target and donor HDD use incompatible versions.
- WD HDDs are sensitive to head map contents. HOT-SWAP is impossible if the target and donor HDD use different head maps.
- Data recovery from a WD HDD requires that the target and donor drives use an identical translator, otherwise complete data restoration will be impossible.

First two conditions can be fulfilled by selection of an appropriate donor drive. Here they are: the donor drive must be a similar model of the same family (the MDL line on HDA case must match), it must use a compatible firmware version and the same head map (it can be verified by reading ROM in Kernel mode). The PCB of the target drive must function normally on the donor HDA.

The third condition cannot be fulfilled by plain selection as there are no two drives with the same P-List tables and, consequently, with identically translators. Therefore, if you need to recover data using HOT-SWAP, you should perform two steps:

1) Based on the first two conditions, select a donor HDD and perform the first HOT-SWAP during which you should test the firmware modules. In particular, you must verify the integrity of the translator modules ID=20h, 25h or P-List table, ID=43h (please see 6.1.2. and 8.1.2.6). Then these translator modules must be copied to the donor drive (remember to preserve a backup copy of the original donor modules). If the translator modules are corrupted, overwrite the P-List module and «Regenerate translator using P-List».

2) Use the donor thus prepared to perform the second HOT-SWAP after which you can attempt recovery of user data with the help of Data Extractor.

9. HDD self testing

The mode for detection and addition to P-List of damaged sectors and tracks revealed during internal self-testing of HDD surfaces is very efficient. SelfTest can be started for any drive with completely functional firmware and the service area, which does not contain any modules having incompatible version. The reading/writing heads of the drive should also function normally. In that case SelfTest is likely to pass all tests and complete successfully.

9.1. Preparation for SelfTest

Prior to the launch of self-testing, you will have to arrange your workspace for it. You will need an external power supply unit (a standard PC power supply); its case must be connected by a conductor with the case of the computer, where the PC-3000PCI tester board is installed to level their potential. There must be sufficient space around the power supply unit to place the drives intended for self-testing. The drives must be located quite close to the host computer so that each of them can be connected by a diagnostic cable to the PC-3000PCI tester board without the need to move it (port #is recommended for SelfTest).

9.2. SelfTest launch

Connect all HDD for self-testing to the external power supply unit and switch them on. Then connect to the first drive a cable from the PC-3000PCI tester board and launch the utility in «Normal» mode, then select «Tools», «Utility extensions», «SelfTest» and run the «Launch SelfTest» command (please see section 5.1.2.1). After the initialization procedures and launch of the first internal test on the drive you should run the «Interrupt status monitoring» command, close the SelfTest dialog and exit the utility, **leaving PC-3000 running, because testing on another port may be** running at the same time. Then disconnect the interface cable from the HDD running SelfTest (the drive must remain powered) and connect it to the next drive, then repeat the procedure described above. Proceed in that manner with all the drives prepared for self-testing.

The drives must be powered by an individual power supply unit throughout the whole SelfTest process, which may last 3 to 6 hours. During that time, you can use both ports of the PC-3000 PCI tester board for diagnostics and repair of other drives. Alternatively, you can leave port #1 connected to the HDD with the largest capacity among the ones being tested for SelfTest monitoring. Then testing completion on it will act as a signal to check the remaining HDD.

9.3. SelfTest completion

Sometimes you have to review regularly the progress of HDD self-testing. To do so, you should connect them (still powered) in turn to the PC-3000PCI board and run the utility in «Self Test Monitor» mode (please see section 5.3). If the self-testing procedure is over, you should perform the following steps:

Power the HDD off[1] and then on again.

Restart the utility in «Normal» mode, then select «Tools», «Utility extensions», «SelfTest» and run the «SelfTest termination» command (please see section 5.1.2.1).

1) Restore service modules damaged during self-testing, if necessary.

2) Perform «Format using P-List and G-List».

3) Run logical scanning and check HDD operation.

Attention! In certain cases when SelfTest completes with an error, the service area of a drive may become corrupted. Therefore, you are advised to save backup copies of service information as tracks.

Warning! SelfTest will erase all user data.

9.4. Prospects of software restoration

The utility has some yet unexplored aspects pertaining to software restoration of HDD, such tasks include: «Utility start from database», «Disabling head 0», «Calibrator» and optimization of the algorithm used for «recording of serial Flash ROM». The group of utility developers continues to work on program upgrades and design of new methods for restoration of Western Digital drives as well as updates to customer documentation. Please keep track of software and documentation updates that become available on the technical support server.

10. Owerwriting Flash ROM

You can overwrite Flash ROM contents in «Normal» mode (as soon as a drive reports on readiness) or in «Kernel» mode (on a separated PCB). The feature applies precisely to overwriting, as the «Kernel» mode is a software mode of the ROM controller firmware. If a part of ROM contents gets corrupted or erased, the drive will be unable to switch into «Kernel» mode and thus overwriting of Flash ROM on the PCB will be impossible. Then you should unsolder the Flash ROM chip, reprogram it in an external programmer device (not included into the PC-3000 bundle) and then solder it back.

Recording of Flash ROM in «Normal» mode requires that a drive should report on readiness being able to read its service information. In case of a WD Arch-V («Caviar Cyl 16 bit») drive you will have to specify the loader source («Module 61h» from the service area of the drive or «Internal utility loader»).

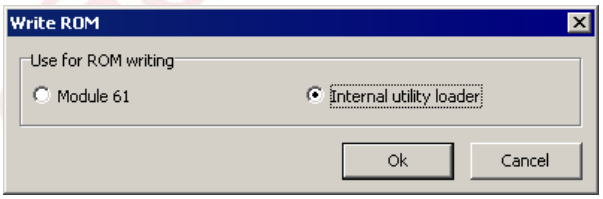


Fig. 10.1.

Selection of the first option will make the utility use for recording the native «Module ID=61h» read from the service area of the HDD. It contains the subroutines for work with ROM (type identification, erasure and recording). Selection of the second option allows to use the «Internal utility loader», which is actually a modified module ID=61h, copied from a known good drive and built into the utility. It is necessary as sometimes the module in the SA may turn out to be damaged, other than native, etc.

A situation may be possible, when the manufacturer changes the type of Flash ROM on drive PCB and the «Internal utility loader» does not support that type; then Flash ROM will not be overwritten. In that case you should use own «Module 61h» of the drive for recording.

[1] – If all HDD are connected to a single power supply unit, you should wait until all drives complete self-testing.

Flash ROM recording in «Kernel» mode requires the PCB only (HDA is not used); the «Internal utility loader» will be employed.

Flash ROM recoding takes a few seconds. If the utility outputs after recording a ROM «writing error», then, perhaps, the drive has a one-time-programmable ROM chip.

In WD Arch-VI («Caviar Cyl 32 bit») drives using Serial Flash ROM recording takes two steps: first the program that controls recording loads into the drive and then the actual writing process starts (it may continue up to 20 minutes).

11. Electrical layout scheme

WD Spartan, Protege, Caviar Arch.V and Caviar Arch.VI HDD use different PCBs and electrical layout schemes. However, the designations of components on PCBs are identical in most cases. That helps using the electrical layout scheme even in cases, when the chart does not match the PCB of the current HDD completely.

11.1. Reference voltage sources

Voltage generators are the first thing that should be checked during diagnostics of malfunction on a HDD printed circuit board (please see elementary diagrams: WDxxxBB/JB R/W Channel, SPINDLE MOTOR Control and WDxxxBB/JB L6278 1.2). WD Spartan, Protege, and Caviar drives use six supply voltages. These are:

- +12V, +5V (supplied from the PC power unit),
- +3.3V, +2.6V (generated by the U6 IRU1329SC stabilizer),
- +1.8V (generated by the U7 chip when an external power regulator is used at Q4)
- and a -5V source, which feeds the preamplifier-commutator chip (generated using the U8 chip of the DC-DC ST755 transducer).

In Caviar Arch.VI HDD the generator of -5V voltage is built on the basis of the FG2M chip and Q3 power key (please see elementary diagram of WDxxxBB/JB Serial ROM, Converter DC-DC -5V). You should by all means check the +5V and -5V supply voltages directly on the - J1 MHA bar connector, i.e. on its contacts 4 and 2 respectively (please see elementary diagram of WDxxxBB/JB R/W Channel, SPINDLE MOTOR Control). The malfunction may manifest itself as a deviation or absence of supply and reference voltages because of stabilizers, power keys or their control circuits, which are out of order. You should also check filter chokes L2, L4, L5, L6, which may cause absence of supply voltages when broken.

Supply and reference voltages must be tested using a digital millivoltmeter and an oscilloscope. The voltmeter determines voltage values while oscilloscope demonstrates pulsations.

11.2. Spindle motor and positioner controller circuit

The spindle motor control circuit in WD drives may be based on L6278 1.2 or on a L6278AC/AH chip. These chips have various packages with a different number of pins. They are incompatible though their functionality is practically identical. These chips use several supply voltages: +12V, +5V and +3.3V. The chip is controlled using software means via its serial bus. The SHUT-DOWN line is used by the microcontroller to activate the spindle motor controller circuit, -5V transducer and the read channel chip. At power-up and upon detection of system-wide reset with a subsequent initialization of microcontroller the line must generate a log. "1" signal; then the phases of the spindle motor will demonstrate starting phase-switching pulses with a 12V amplitude. If you disconnect the load (the spindle motor) by removing the board from its HDA case, then the outputs of three phases of the L6278 chip will produce clear rectangular two-level pulses with the amplitude of 6 and 12V. The "midpoint" output should exhibit static 6V level (small needle-like bursts at phase switching are allowed).

Please note that the spindle motor does not spin up in Safe Mode and so diagnostics of the spindle motor controller chip must be performed in normal mode (with all configuration jumpers removed, please see Safe Mode for details). In case of L6278 chip outage and prior to its replacement (especially if its case shows visible damage or overheating) make sure to check the supply voltages and load-bearing auxiliary components (D1, D2); please use a resistance meter to test the resistance of spindle motor coils (phases), which should be 2,2 Ohm.

11.3. Data reading channel

The data reading channel is built on the basis of the 50G6474 chip manufactured by WD. It is quite reliable and fails rarely. Its diagnostics requires a check of supply voltages (3.3V) and operation of built-in 1,8V regulator based on an external Q4 key. Then you should check excitation of the Y1 clock generator.

12. Appendix. Supported drives

Support for WDC drives consists of 3 utilities. This is due to differences in the architecture drives.

12.1. HDD, supported by the utility «Caviar Cyl32»

Drive family	Model codes
Invader XL2	AU, BN, BP
Invader XL3	BS, BT, CC, CD, CF, CL, CM, CT
Maverick	CA, CB, CJ, CR, CU, CV, CW, CX, CZ, DM, EE, EK
Pioneer	DA, DB, DU, DV, EC, ER, FF
Eclipse Xenon Trailblazer Puma	DE, DG, EN DJ, DK, DN, DR, DT, EA, EB, EP, ET, EU, FH, FR, HN DW, DY, ED, EV, FB ES
Aspen	FD, GC, GD, GZ
Eclipse II	GF, GG
TB Eagle	GT, GU, GV

See Fig. 12.1, 12.2

12.2. HDD, supported by the utility «Caviar Cyl32 SATA»

Drive family	Model codes
Safari	EL, EW, FE, FN, FP, GH, GW, GY
Expedition Polaris	FK, FL FY, FZ, GB
Eagle Hercules	JF, JG, KB JZ, LE, NM, NN, PK, KR, LD, NA, NB, NS, PL, NR
Odyssey	MM, NL, NP, RA, SK, SL

See Fig. 12.3, 12.4

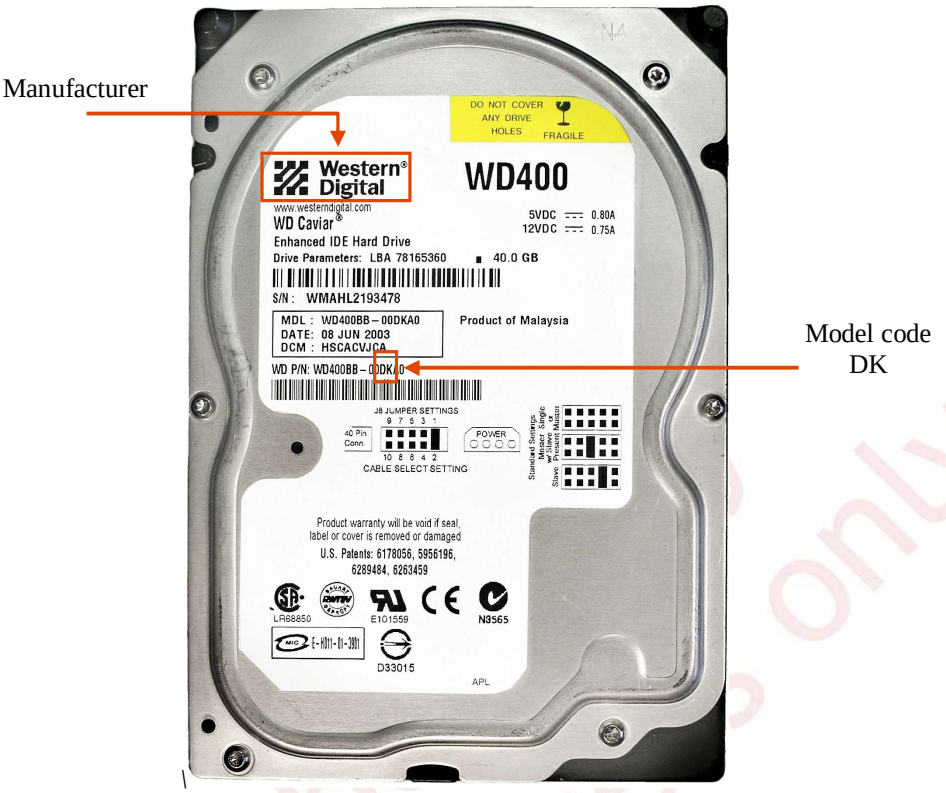


Fig.12.1.

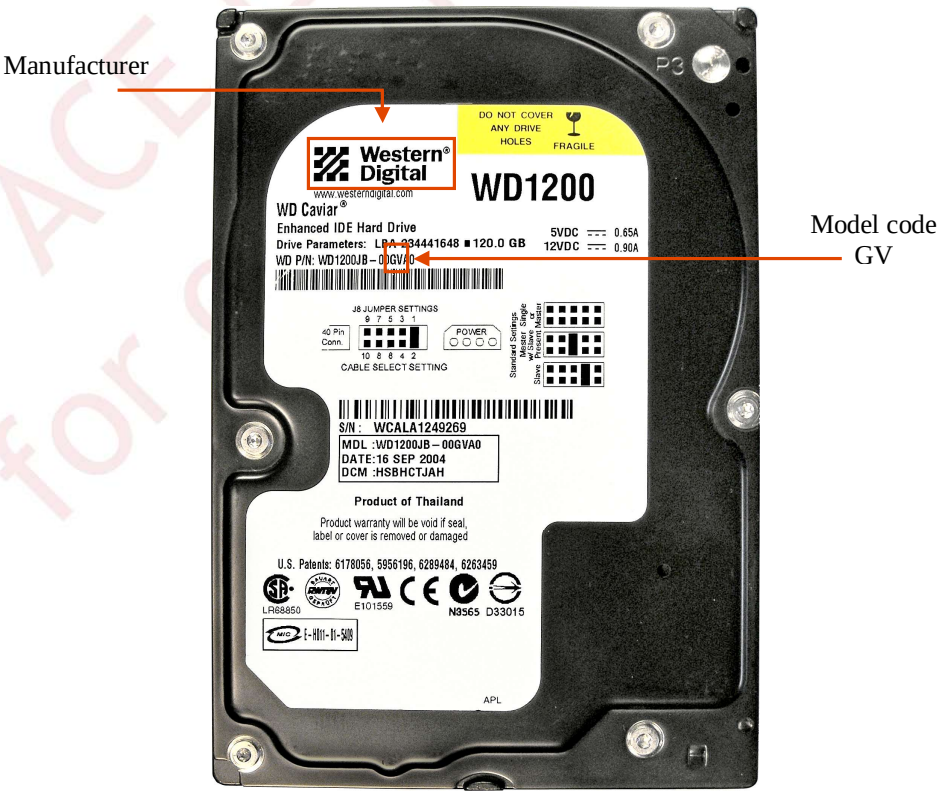


Fig.12.2.

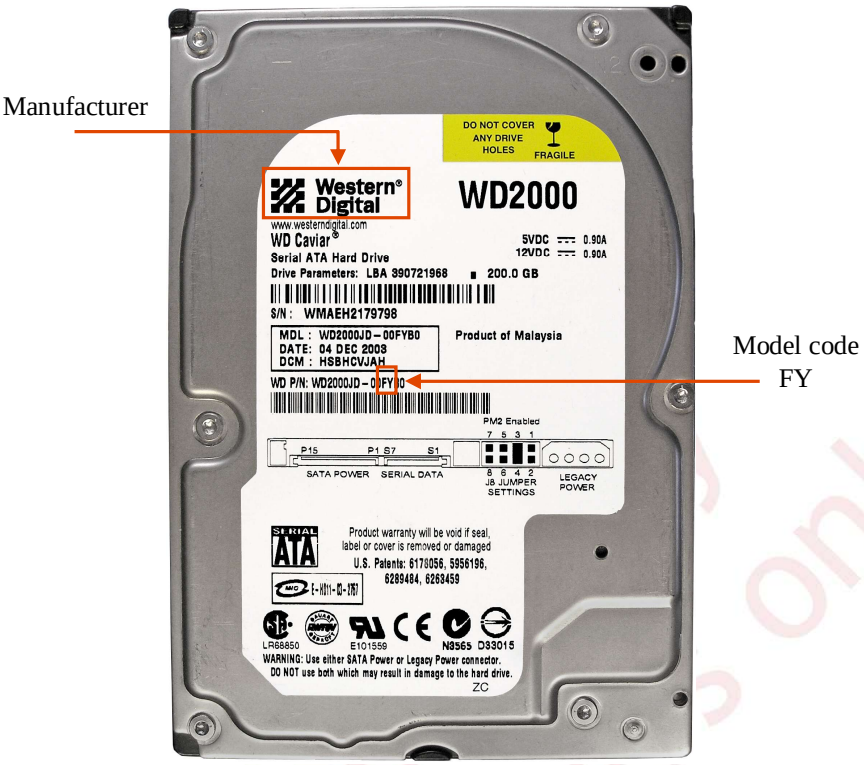


Fig.12.4.

Fig. 12.4.