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Agilent
Hard Disk Read/Write Test System

E5023A Electronics Package
E5010C Split Axis Spin Stand
E5013A Combined Axis Spin Stand

A Head Test System
for Today and Tomorrow

Agilent Technologies

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State-of-the-art heads require a state-of-the-art test system

The aerial density of hard disk drives (HDD) increases about 60% every year. The increase in capacity of hard drives depends on both the ability to write and read more bits per lineal inch and to make tracks narrower and closer together. This translates into greater need for higher bandwidth electronics and more accurate mechanical positioning.

The retail price per gigabyte of hard disk capacity is also decreasing each year. These trends place greater demands on the technological innovations needed to stay current in this business.

Some test equipment is designed once and sold for years with no changes, Agilent's E5023A Electronics Package contains electronics modules specifically designed for use in a system suited to a rapidly changing environment. The E5010, E5011, and E5013 series spin stands are supported by the E5023A Electronics package. The modular format allows for flexibility as technologies advance.



Applications

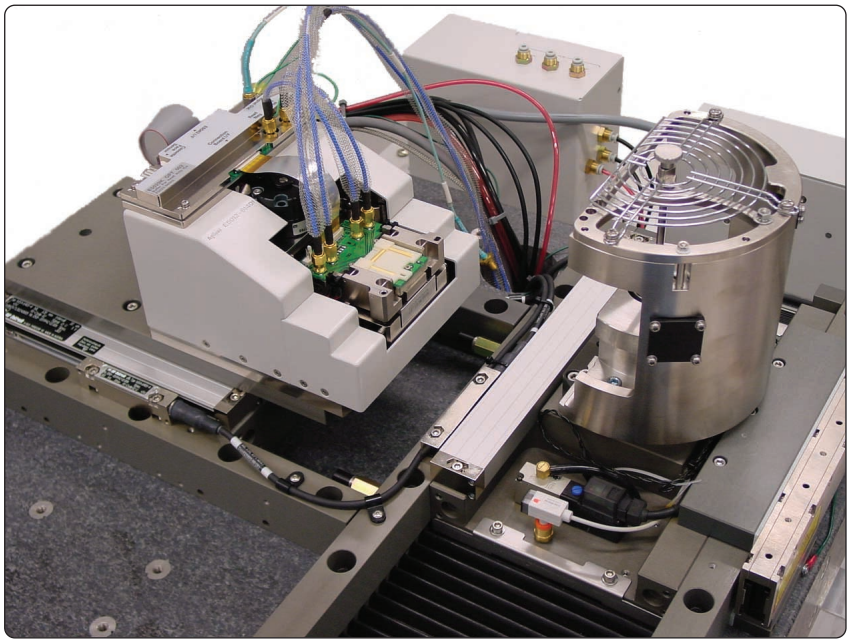
Hard disk drive manufacturers find Agilent's Hard Disk Read/Write Test System valuable in the following functional areas:

- Advanced R&D labs
- Head R&D labs
- Channel R&D labs
- PRML channel and HDD project labs
- Head manufacturing
- Incoming inspection
- Failure analysis

System highlights

- High bandwidth and TPI
- Lower cost upgrades and customization
- High throughput
- High flexibility for implementing new measurement needs
- Calibrated system, signal injection not required
- No mechanical alignment when changing HGA programs, just data editing
- Worldwide support and service

Agilent's Hard Disk Read/Write Test System contains state-of-the-art mechanical and electronics components. This product overview provides information on the key components and capabilities of the system .



E5010C Split axis spin stand

Mechanical

What's new?

There are several key changes from the Agilent E5010B spin stand. Both the E5010C and E5013A spin stands mark the introduction of a new Head Load Mechanism and associated cassette amplifier. At introduction these components will provide greater than150K TPI capability.

Spin stand common characteristics

After coarse moves the X and Y stages have the air replaced by a vacuum thus locking the stages to the Granite. This results in the X and Y stages becoming literally as solid as a rock.

There are clamp options available to support 1.8, 2.5, and 3.0/3.5 diameter disks.

The coarse X and Y positions, as well as, the spindle RPM are controlled by means of an RS-232 data link directly from the PC to the motion controller. The DSP based multi-axis controller can easily handle this application.

Either an "up" or "down" head is held on the top surface of a disk. As part of the system setup the user describes physical dimensions of the head-to-disk geometry so that the system can match the skew-versus-track number behavior of the target drive or the user can specify the track-and-skew angle independently. Mechanical alignment is not required when using new HGA geometry, rather a few dimensions simply need to be updated in a data file.

The new 150K TPI type spin stands are controlled by the E5035B spin stand interface VXI module.

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E5010C Split axis spin stand

The split axis spin stand has separate coarse movements for the electronics and for the spindle. This spin stand rests on the floor.

The enhanced “C” version of this spin stand provides greater than 150K TPI. It has the same X and Y stages as the prior version and has a completely redesigned head load mechanism (HLM). This includes a complete redesign of the head amplifier mechanical configuration and the piezo is now located above the HLM, instead of below the HLM. The motion control electronics package is mounted below the spin stand in the same frame.

Once the head is loaded the arm of the HLM is locked down in a much more solid way than in prior designs improving the TPI capability.



E5013A Combined axis spin stand

E5013A Combined axis spin stand

The E5013A version also a greater than 150K TPI spin stand and has a new HLM like the E5010C.

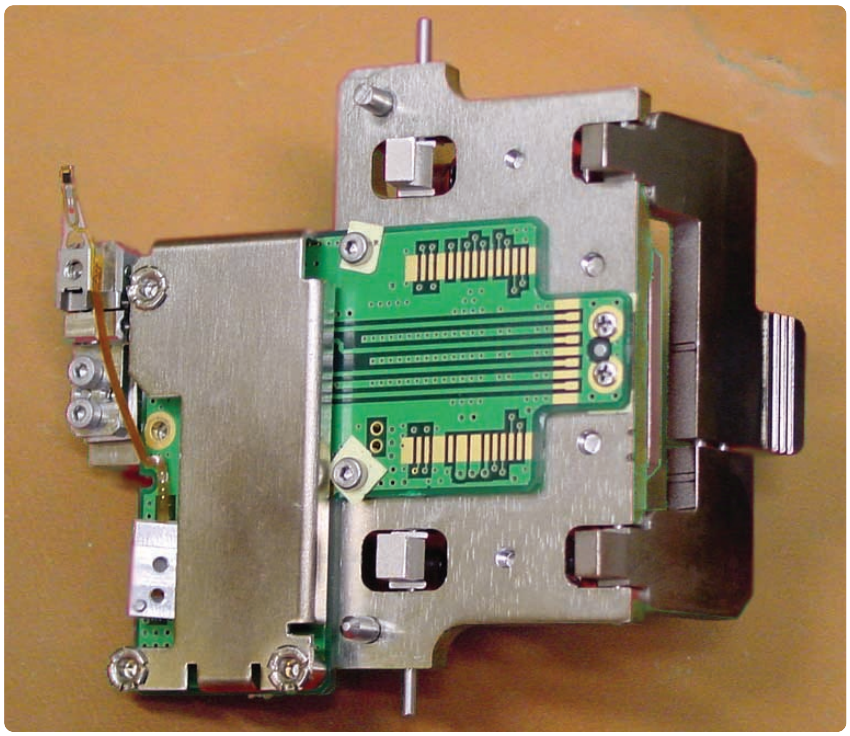
The combined axis spin stand has the spindle fixed to the granite and the X and Y coarse movements connected in series. The HLM floats on air during a move and locks by vacuum after a move.

The granite is half the size used on the split axis versions. By moving the motion control electronics into a separate enclosure separated from the spin stand, heat and vibration from this source are eliminated.

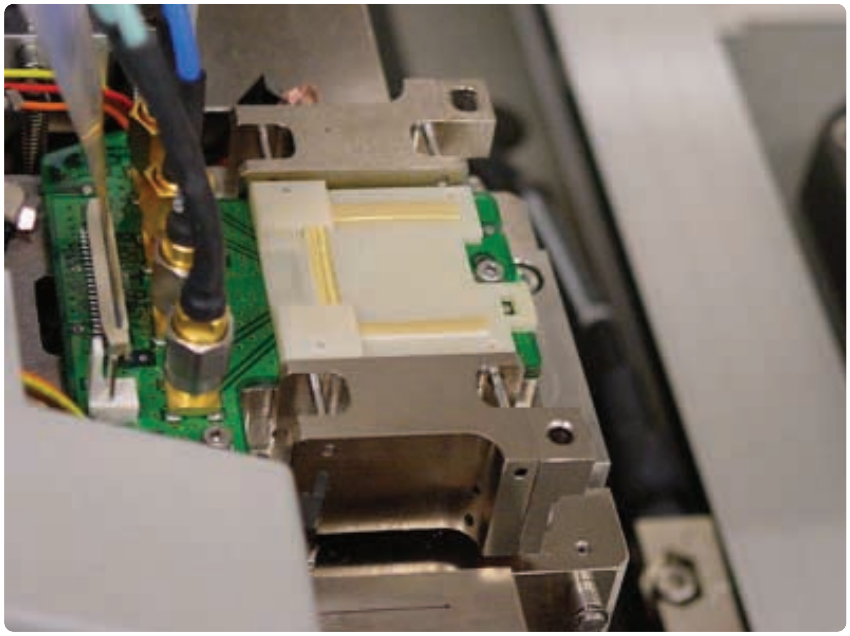


E5013A Spin stand control electronics

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Combined E5029K amplifier and E5029E cassette with HGA attached



HLM interface to the cassette amplifier

Amplifier cassette

The cassette is the mechanical interface between the spin stand and the head gimbal assembly (HGA). One side connects electrically and mechanically to the spin stand and has an optical shutter that tells the system if the head is facing “up” or “down”.

The Z-height setting is fixed by a shim in the cassette. The Z-height can be verified using the optional Z-height measuring tool.

Since the dimensions of the suspension and location of the electrical contacts vary with each drive manufacturer and program, the cassettes are custom made based on customer furnished drawings and samples of their HGA.

Pogo pins are no longer used to contact the HGA flex circuit. This reduces the inductance in the writer circuit, as well as increasing reliability and repeatability. Similarly, pogo pins are no longer used in the electrical interface between the cassette amplifier and the HLM.

The amplifier electronics printed circuit board can be replaced to support a different amplifier or sometimes a different HGA if the dimensions are close to the original design.

The E5029C/D cassettes used on prior spin stands supported different length flex circuits. The newer E5029E cassettes used on the E5010C and E5013A are more rigid and are not adjustable for flex length.

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E5023A Electronics package

What's new?

There are several key changes from the Agilent E5022B model. The maximum data rate is now 1.5 Gbps. The electronics package also changed from using a write plus and write minus pulse for each data edge to using a differential NRZ data and differential clock format. To allow for system upgrades of either the spin stand or electronics there is a new E5043 head amplifier control unit. The "A" version is for use with the newer 1.5 Gbps systems and the "B" version is compatible with existing systems. The E5035B is a new spin stand controller for use with the E5010C or E5013A spin stands.

VXI modules

The heart of the system is a set of custom designed C-size VXI modules. These modules contain DSP intelligence that allows the PC controlling the system to do so without communicating during the actual testing. Control and communication with and between modules is register-based and provides very high speed. The system ships with an IEEE-1394 Firewire® slot zero interface between the PC and the VXI cage.

Open hardware architecture

Separating the electronic functions into VXI modules allows system upgrade capability on a module by module basis. This approach allows more flexibility.

VXI is an open hardware platform. There are a large number of vendors offering a variety of VXI products. Unused slots in the VXI cage might even be used to install third party modules. For stand-alone test instruments using the GPIB (IEEE-488) interface, integration into the system is straightforward.

E5035B Spin stand interface module

The E5035B spin stand interface module is needed when controlling the new 150K TPI type spin stands. The E5035B has the fine positioning control capability for the piezo stage. Some of the amplifier control functions have been moved from the E5035A into the new E5043A/B.

The E5035B one-slot wide VXI module receives index pulses from the spin stand. The module acts like an orchestra conductor by sending trigger pulses to the other instruments in the system thereby controlling the timing of all the measurements. Note that the PC only sets up the tests but does not directly control them during actual testing. This is part of the reason for the high throughput of this system. The E5035B spin interface is needed to control the E5010C or E5013A spin stands.



VXI card cage: E8491B, E5035B, E5037C, optional E5039B, E5036A, E5038B, E5040A

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E5036A Filter matrix module

This is a one-slot wide VXI module that holds up to four lumped element filter daughter boards. Standard fifth order Butterworth low pass filters are available with cutoff frequencies of 100, 150, 200, 250, 300 and 400 MHz and others are available to order. Straight through and blank boards are also available.

There are four outputs that have been through one of the filters and in addition two outputs that have not been filtered.

In older test systems the filters were used for separation of the overwrite signals but in this system overwrite filtering is done using a spectrum analyzer. The main function of the filters is to set the system noise bandwidth. Each filter board has EEPROM memory that knows what type of filter it is and also holds calibration data.

This module also contains an input attenuator and amplifier. System gain is set so that all its outputs are about 300 millivolts. The combined gain of the head amplifier and the filter matrix module is available in the system software so that the instrument amplitude readings can be scaled to head terminal voltage.

E5037C 1.5 Gbps data generator module

This one-slot wide VXI module generates the data patterns that are written to the disk at rates up to 1.5 Gbps. This data is used for almost all measurements. The data generator module has the ability to internally generate any desired data pattern.

Note that in the case of BER testing, data is generated in the PRML channel chip independently of the data generator module.

The E5037C data generator uses differential NRZ data format compared to prior E5037 versions, which used a pulse for each data edge. Between any version data generator module and the head amplifier there is now an amplifier control box. The E5043A is used with the E5037C and the E5043B is used for the E5037A and E5037B. Customers can upgrade their spin stand without also upgrading all of their existing electronics.

E5038B 1.5 Gbps parametric measurement module

The E5038B has higher performance capability in terms of measuring narrower pulses than the “A” version.

This two-slot wide VXI module contains the measurement hardware for track average amplitude (TAA), pulse width (PW50) and base line (BL). Each of these parameters is digitized every 5 microseconds and data is stored in the module’s memory. It is available averaged for a complete rotation, as individual data packets for each measurement, and in various statistical forms. This module is calibrated considering the effects of frequency, pulse width, and signal level with data stored in EEPROM memory. This is a three dimensional calibration, not a simple single frequency amplitude calibration. This module makes these measurements much faster than those performed using a scope do.

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Optional E5039B 1.2 Gbps bit error rate module

The E5039B supports up to 1.2 Gbps data rates. This one-slot VXI module holds the optional daughter board that is customized for an individual read channel chip. Software control of all the registers in the chip is provided as function calls to a DLL. The errors are counted in hardware in the BER module on the user side of the channel chip.

E5040A 500 MHz Spectrum analyzer

The narrow band measurements are done with the E5040A VXI spectrum analyzer. Note that since the data patterns used for the narrow band tests are considerably lower than a 1T rate, 500 MHz is adequate for a 1.5 Gbps system. In order to see a wider band spectrum plot a customer-furnished Agilent 4396B rack mount analyzer is supported for spectrum display modes only.

Optional E5041A dual counter popcorn module

The standard system can measure popcorn noise using a statistical method based on the E5038A/B parametric module, but if threshold based popcorn measurements are desired the E5041A module can be added.

E5041A is a dual counter module designed to detect and count popcorn noise. It has two threshold levels that detect popcorn noise for both positive and negative amplitudes of the input signal.

Calibration

Agilent (formerly the T&M division of Hewlett Packard) has a long history of making test instruments for many industries. A common feature of most of these is that the instrument is calibrated with tractability to a national standards lab like NIST. When Agilent originally introduced the Hard Disk Drive Head Test System, Agilent brought calibrated measurements to the head test field. If a module is swapped the overall system calibration stays intact because each module has its own calibration data stored in EEPROM. The fact that the systems are calibrated means that the test results from the same head and media will give the same answer, something that does not happen now with uncalibrated test systems. This shortens HDD time to market because time is not wasted trying to determine why there are big differences between the vendor, R&D lab and production floor.

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Other electronics

Computer

The PC (and CRT display, LCD optional) furnished with the system comes with both a CD-ROM drive and RJ-45 LAN connection to allow loading software from either CD-ROM or over a network connection. A 3.5" floppy drive is also included. Interface cards for GPIB (IEEE-488) and Firewire (IEEE-1394) are installed.

Read/write amplifier

Agilent has a universal head amplifier design made with discrete components with very wide bandwidth for measuring the performance of a head without degradation due to limited performance of commercial amplifiers. In addition, many of the popular commercial amplifiers both public and customer-furnished proprietarily are offered as options. These amplifiers contain EEPROM memory with identification and calibration data. Mechanically the amplifier is mounted on the HGA cassette to reduce the distance between the amplifier chip and HGA contact.

Optional oscilloscope

An option is available to add an Agilent 54845A 8 GS/s oscilloscope to the system at any time.

When the oscilloscope is included in the system non-linear transition shift (NLTS) by the time correlation or di-pulse extraction methods can be measured. The read head signal waveform can be seen and measured in the software by means of the oscilloscope. The oscilloscope is triggered from the spin stand interface module and has setup and data interface via GPIB.

Electrostatic discharge (ESD)

State-of-the-art HDD heads are extremely sensitive to ESD and the newest designs are the most sensitive. The materials used in the system have been chosen based on ESD considerations. The electronics have special circuitry designed to minimize potential ESD damage to the head being tested.

Specifications, software, firmware, updates, manuals

Firmware and software determine the functionality of the system. Because of the dynamic nature of the HDD business the test system needs to be easily upgraded. The lastest version of firmware, software and documentation is available to download free at: **http://dst.tm.agilent.com**

Specifications

Note that the system specifications can change with each software change. Revisions typically involve adding new features and capabilities to the system. The specifications are part of the downloadable operation manual rather than being a separate document.

Diagnostic software supplied in VEE and Visual Basic

The system ships with diagnostic programs in VEE and Visual Basic that allow the system operation to be confirmed or for a quick engineering test.

Test executive SL E2011E actions supported

Some users want a packaged test executive to allow a non-programmer to set up and run a sequence of tests. This could be supported by means of an Agilent product called Test Executive SL. A library of "actions" comes with the system. For more on Test executive SL see: **www.tmintl.agilent.com/testexec/prod_info.shtml**

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Open software architecture supports customer developed software

In addition to the open hardware architecture, the system software is open at the DLL function call level. This allows customers to develop their own application software. Most HDD manufacturers have many proprietary test algorithms that only they will code into tests. The application development language that the customers use is only limited to those languages that can call functions from a Windows DLL like Agilent VEE, Visual Basic, LabVIEW®, C++, and others.

There is also a provision for a user-defined sequence (UDS) of tests. The UDS is constructed using DLL functions running in the PC. In this mode, the complete test sequence is controlled by DSP based modules without the intervention of the PC, thereby allowing the sequence to run very quickly.

Updates

The DSP firmware in the various modules is stored in EEPROM memory that can be updated by the PC. This is typically done automatically with each change in the system software version number. As part of the test setup process, data is stored in the RAM memory associated with the DSP chips in each module. The firmware is not changed for each test.

Software upgrades have been released about once a month and are typically downloaded from Agilent's website by customers directly into their test systems and then installed locally. Upgrades might include enhancements, fixes, or added test functionality for the system. For example, since the E5022B's original shipment, functionality has been added in the areas of:

- Ability to compensate for thermal drift.
- Ability to erase a band that is wider than the piezo move range.
- Ability to find a track using a different head than was used to write the track.

Manuals

The following manuals are included as part of this system and are available directly from the worldwide web:

- **Site Preparation and Installation**
  Covers requirements for compressed air, vacuum, electrical power, floor space, ESD, and more, as well as a step-by-step procedure to assemble the system.
- **Operation**
  Covers setup, troubleshooting program operation, measurement definitions, and contains current specifications.
- **Programming**
  Explains the "all in one", "setup and measure" ways of writing code and provides some examples. Most of the manual provides detailed documentation of the function calls. There is a separate manual for the higher throughput "user-defined sequence" method of writing code.
- **Software Installation**
  Contains a step-by-step procedure to install or upgrade the software using CD-ROM, floppy disks or the web.
- **Service**
  Also available on the web are sections of the service manual related to troubleshooting to the module level, changing the disk clamp, repair of the spin stand(s), and more.

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Customizing head amplifiers, PRML chips, cassettes

Three parts of the system require customization for use with the particular HGA hard drive program at the customer's site. These parts are the cassette to hold the HGA, the head amplifier, and optionally the PRML channel chip. For the latest information on these parts consult your Agilent representative listed on the back page of this brochure, call the support phone number 800-452-4844, or visit the Agilent head test web site at **www.agilent.com/find/headtest**

Option to upgrade earlier systems

- E5023U Opt 001- 1.5Gbps and Spin stand control electronics
- E5010V Option 001* - Spin stand (with serial numbers <= 16662)
- E5010V Option 002* - Spin stand (with serial numbers > 16662)

* *Requires shipping spin stand to Kobe, Japan*

Configuration

Typical components of the > 150K TPI and 1.5 Gbps hard disk read/write test system include a spin stand (E5010C or E5013A), the E5023A electronics package, a customized E5029E cassette to hold HGA, an E5029K amplifier customized for HGA and chip, and any needed options.

Options might include: an 8 Gsps oscilloscope, an E5039B BER module, a customized BER daughter board with PRML chip, or a filter selection for E5036A

Web references

Additional information is available by visiting: **www.agilent.com/find/headtest**



E5023A shown with optional 8 Gsps oscilloscope and E5010C Spin Stand

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Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

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(fax) (31 20) 547 2390

Japan:
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(fax) (81) 426 56 7840

Korea:
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(fax) (82-2) 2004-5115

Latin America:
(tel) (305) 269 7500
(fax) (305) 269 7599

Taiwan:
(tel) 080-004-7866
(fax) (886-2) 2545-6723

Other Asia Pacific Countries:
(tel) (65) 375-8100
(fax) (65) 836-0252
Email: tm_asia@agilent.com

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