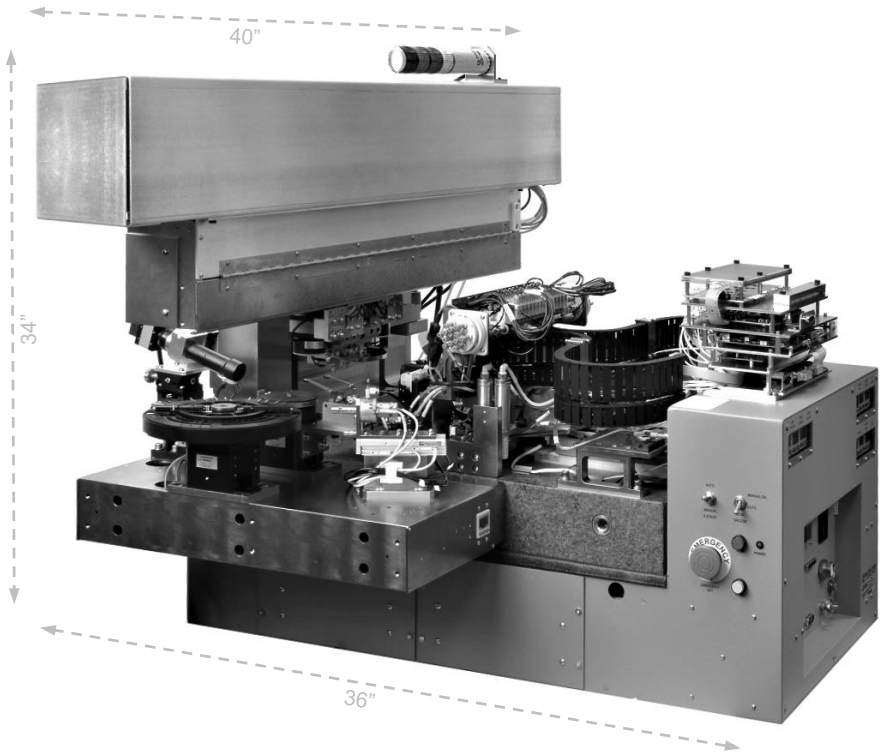
http://www.guzik.com/products/head-and-media-disk-drive-test/spinstands/

GUZIK Technical Enterprises

V2018 SPINSTAND
AND NEW SERVO-8 SYSTEM

Designed for Automated High-TPI HGA Volume Testing



Up to 1300 kTPI Estimated Capability

Automatic HGA Loading for Improved UPH

At least 10x Times Faster Servo Writing

New Servo-8 Control System

Down to 0.19 nm (1σ)
NRRO in servo mode

Down to ±0.35 nm (pk-pk)
positioning repeatability

Less than **11 sec** head swap time

New V2018 Spinstand addresses the limitations of V2002 Spinstand in high-TPI Head Gimbal Assembly (HGA) testing: it incorporates precision glass scale encoder and piezo actuator located close to the HGA mounting block. This design delivers up to 2.7 kHz closed loop bandwidth, critical for fast and accurate servo writing. It improves the servo writing uniformity at least an order of magnitude and allows high-TPI testing.

US patents 9,773,515; 9,443,542; 9,842,981; 9,627,602; 7,061,235 US patent pending

MAJOR HIGHLIGHTS

- Automatic HGA Loading for improved UPH with less than 11 sec HGA swap time
- Better uniformity and accuracy of servo writing for high-TPI HGA testing
- At least 10x times faster servo writing[1]
- High-bandwidth servo significantly reduces spindle warm-up time
- New servo control and capturing tolerates damaged servo sectors[2]
- Up to 34 um usable radial positioning range[3]
- Innovative charge based piezo actuator control for highly linear actuation[4]
- Automatic closed loop adjustment software
- RRO compensation for both piezo-servo and micro-actuator loops up to the loop bandwidth
- Patented HGA collet for stable and precise HGA position on the HGA tooling without mechanical damage to the HGA[5]
- Optical alignment of HGA flex pads for reliable electrical contact
- Up to 30 HGAs per tray, up to three trays per spinstand[6]
- Optional HGA serial number recognition camera
- Integrated light tower for tester status visual indication on production floor
- Crash-proof XY-Positioning to protect spindle[7]

[1] With comparable servo quality on V2002 system with PAC cartridge
[2] Can tolerate up to 10% of invalid servo sectors per revolution
[3] With 60 mm piezo; piezo options available: 18 mm, 40 mm, and 60 mm for optimal combination of mechanical bandwidth and positioning range
[4] Residual piezo hysteresis is 1% of the full displacement range or less
[5] US patent 9,443,542
[6] Three trays design can be delivered by request
[7] US Patent 7,061,235

OVERVIEW

Guzik V2018 spinstand is targeted for volume HGA testing in both pre-production and engineering labs.

New V2018 Spinstand addresses the limitations of V2002 Spinstand in high-TPI Head Gimbal Assembly (HGA) testing. The low bandwidth of V2002 glass scale based closed loop positioning system restricts the uniformity of servo writing, making it almost impossible to write servo with high-TPI HGAs.

To facilitate faster throughput and greater testing accuracy V2018 spinstand introduces the following major features and improvements compared to the previous generation of V2002 spinstands:

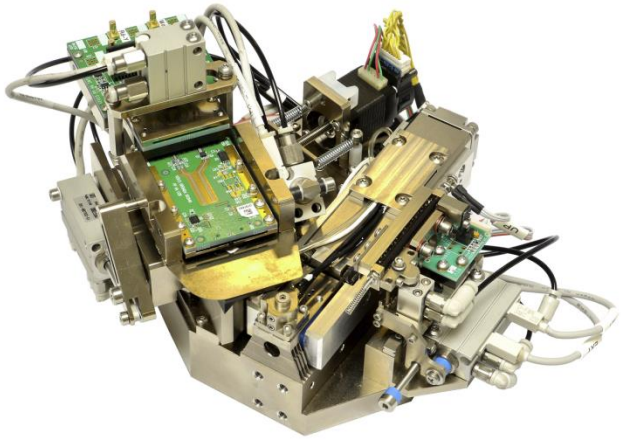
- New V2018 HGA tooling incorporates precision glass scale encoder and piezo actuator located in close proximity to the HGA mounting block. This design delivers up to 2.7 kHz piezo-scales closed loop bandwidth[1], critical for fast and accurate servo writing with at least 10x times faster servo writing and capturing[2]. It improves the servo writing uniformity at least an order of magnitude and allows high-TPI testing.
- V2018 Spinstand can automatically load HGAs from the HGA tray to HGA tooling and unload them back. HGA loading automation allows performing batch testing of HGAs without operator's involvement. This improves UPH and effectively prevents many human errors that could be introduced in manual installation of the HGA. Optical alignment of HGA flex pads assures reliable electrical contact for all types of pads configurations: multi-row and narrow width.
- Charge based piezo actuator control provides big advantage over traditional piezo voltage control used in all previous Guzik spinstands: position has linear dependency on the piezo charge and has minimal hysteresis. This increases the closed loop bandwidth compared with voltage-controlled closed loop.
- Reconfiguration of V2018 Spinstand to the new test product takes less than 30 minutes: mechanical alignments of the HGA tooling are performed outside of the spinstand using Optical Measuring Machine (OMM). After installation final alignment is performed by interactive software using the built-in video camera.
- Servo-8 control system introduced in V2018 spinstand implements advanced positioning control schemes and RRO compensation with all servo closed loop modes. It can tolerate damaged servo sectors during servo writing. It comes with closed loop tuning software, which performs automatic adjustment of the most of the closed loops.

As a result, V2018 Spinstand increases the system testing throughput at least two times due to much faster radial positioning and reduced overhead for HGA loading/unloading.

[1] 2.7 kHz piezo-scales closed loop bandwidth is achieved for 18 mm piezo models. Longer range piezo models have smaller bandwidth. See *Specifications* section for details

[2] With comparable servo quality on V2002 system with PAC cartridge

NEW HGA TOOLING



Guzik V2018 spinstand features new modular HGA loading mechanism designed specifically for automatic HGA placement. This new design called *HGA tooling*.

It is based on PSC cartridge design inheriting essential design ideas. It incorporates integrated glass scale encoder and piezo actuator. The piezo actuator and glass scale encoder are installed as close to the HGA as possible, so the piezo actuates only small mass delivering much higher control bandwidth compared to traditional main piezo approach with more than 20 times improvement in the closed loop bandwidth[1]. High bandwidth of the piezo-scale closed loop enables quicker and much more accurate servo writing required for modern high TPI heads.

The new HGA tooling has improved multi-point self-leveling HGA retaining mechanism on the HGA mounting block, which is called the *collet*. The collet delivers solid but gentle grip of the HGA on the mounting block without any damage to the HGA boss hole rim (US patent US9443542B1).

The head amplifier board on the HGA tooling is positioned much closer to the HGA contact pads with short electrical connection between contact pads and preamp IC made through one set of the pogo pins. This improves electrical performance and preamp IC cooling over V2002 designs. The head amplifier board is located on the tilting platform, which tilts back when the HGA needs to be replaced.

POSITIONING IMPROVEMENTS

A significant improvement over traditional Guzik spinstands is the introduction of the charge-based piezo actuator control. In V2018 control system the piezo displacement is controlled by changing the piezo charge in the closed loop. The piezo charge control provides big advantage over traditional piezo voltage control used in all previous Guzik spinstands: position has linear dependency on the piezo charge and has minimal hysteresis. The residual hysteresis is equal or less than 1% of the full piezo actuator stroke range. This increases the closed loop bandwidth compared with voltage-controlled closed loop.

Linearized glass scale position feedback combined with low actuated mass and highly linear piezo actuator greatly increases the micro positioning speed: it dramatically reduces position settling time by achieving

[1] Compared to 120 Hz main piezo-scales closed loop bandwidth for V2002 Spinstand. 2.7 kHz piezo-scales closed loop bandwidth is achieved for 18 mm piezo models. Longer range piezo models have smaller bandwidth. See *Specifications* section for details.

higher speed of movement without overshoots and undershoots. Higher positioning speed and lower settling time leads to **2x time** improvements for offset scan operations, such as track profile measurement and band erase procedure, compared to V2002 systems.

Improved positioning in non-servo mode has multiple benefits:

- It lessens the negative effects of the radial thermo-drift during servo writing, which in turn improves the quality of written servo as written signal is more uniform and less distorted across the servo range.
- It allows writing servo for modern heads above 1000 kTPI track densities.
- It produces better servo capturing results: “Regular” quality servo capturing on PSC systems delivers similar servo performance as “High” quality servo capturing on V2002 systems. This translates into more than **10x time reduction** for servo writing and capturing procedure.

Faster servo writing alleviates the problem of changing RRO during spindle warm-up period, greatly reducing spindle warm-up time required for normal servo operation from hours to minutes.

SERVO-8 CONTROL SYSTEM

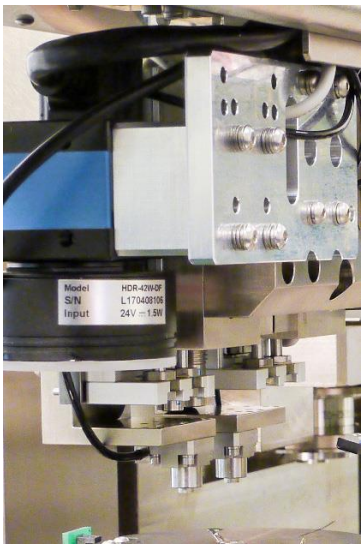
Servo-8 control system introduced in V2018 spinstand implements advanced positioning control scheme and RRO compensation with all servo closed loop modes, piezo-servo mode and micro-actuator mode.

New Servo-8 control scheme can now operate with non-zero amount of damaged servo sectors (as opposed to the traditional servo control scheme, which requires all servo sectors to be decoded during servo writing and capturing). This greatly reduces the probability of failures during servo writing and capturing due to local media defects and allows testing media with defects in servo zone.

Servo-8 is accompanied with advanced closed loop tuning software, which provides automatic adjustment of charge closed loop, piezo scales closed loop, and micro-actuator closed loop. Interactive loop setup GUI is available for piezo-servo closed loop adjustment. Advanced servo diagnostics software developed for Servo-8 allows visualization of servo defect map and servo capturing results.

HEAD LOADING AUTOMATION

Guzik V2018 spinstand can automatically load heads from the HGA tray to HGA tooling and unload them back. Head loading automation allows performing batch testing of heads without operator involvement. This improves UPH (units-per-hour tested) and effectively prevents many human errors that could be introduced in manual installation of the HGA. Automatic optical HGA alignment based on HGA flex pads detection assures reliable electrical contact of flex pads with HGA tooling pogo pins.



The V2018 automation mechanics uses vacuum pickers to clamp, lift, and transport heads from one location to another. Pickers together with video camera (used for optical alignments) are installed on the moving *gantry*.

V2018 has two pickers: one picker is used to bring new HGA from the tray to the HGA tooling, while another picker is used to return already tested HGA from the HGA tooling to the tray. This allows swapping heads between the tray and the HGA tooling in one motion of the gantry, saving test time.

The whole HGA swapping procedure takes less than **11 seconds**.

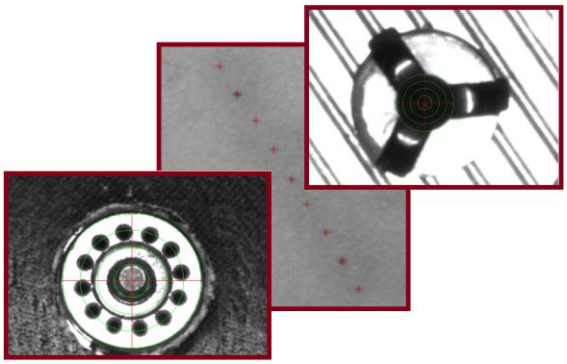
Before placing the HGA on the HGA tooling, it needs to be precisely oriented such a way that when the picker transports the HGA to the HGA tooling, HGA contact pads will be directly under the pogo pins of the preamp. To perform such orientation, the HGA is put on the *aligning table*. While being on aligning table, the photo of the HGA is taken by the built-in camera. Then this photo is analyzed by WITE software to determine the angle to rotate the HGA in order to achieve the desired orientation of HGA contact pads. The aligning table then rotates the HGA by this angle. The picker transports the HGA to the HGA tooling, where it is clamped to the mounting block by the *collet*.

While on HGA tooling, another photo of the HGA is taken. This photo is analyzed by WITE software to determine the positions of HGA contact pads one more time and to compare these positions with the positions of the pogo pin contacts. If software detects too big difference between these positions, it moves the whole HGA amplifier assembly using built-in motor to align pogo pins with HGA contact pads. This mechanism of adjusting pogo pin positions is called *Contact Shift Mechanism* (CSM). CSM compensates for residual contact misalignments without returning the HGA back on aligning table thus saving test time.

V2018 has integrated light tower to simplify visual indication of the tester status on production floor.

OPTICAL ALIGNMENT FOR AUTOMATION MECHANICS

Switching V2018 automation to the new test product (new HGA model to test) is easy job because most of alignment steps are performed using the built-in video camera and do not require any mechanical parts to adjust or align. Interactive software will guide the operator through all alignment steps. The entire procedure takes less than ten minutes to finish. Each step is only a few clicks in the software.

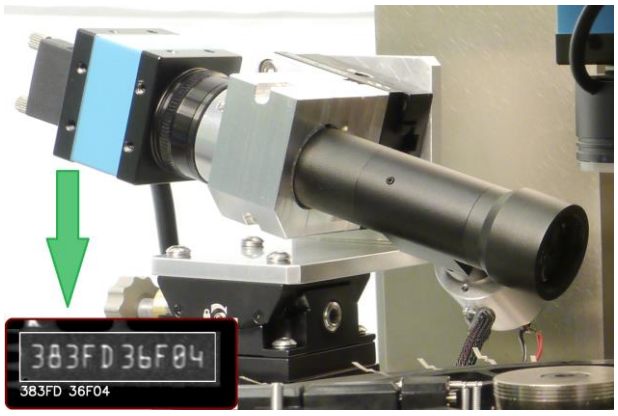


HEAD TRAYS

V2018 spinstand comes with trays for storing heads to be tested. Each tray can accommodate up to 30 heads. A tray has two compartments with individual HGA locking covers to keep heads secured in place during tray handling. A HGA tray is installed by operator on the rotating tray carousel. Automatic tray cover opening mechanism – the *tray screwdriver* – opens and closes tray covers. Automation mechanics take HGAs from the installed tray and put them onto HGA tooling, one by one, for testing.

Trays are made stackable so they can be put one on a top of another while not on a spinstand.

HEAD SERIAL NUMBER RECOGNITION



V2018 spinstand has built-in microscopic camera for automatic optical recognition of HGA serial numbers engraved on the head slider edge.

This is optional component, which can be installed for customers who require this capability.

CRASH-PROOF DESIGN

Guzik V2018 is a crash-proof spinstand due to the patented design of the HGA tooling. The arms of HGA toolings are arranged in V-shaped manner: they are rotated 35 to 45 degrees (depending on particular HGA model) in respect to the X and Y coordinate axes of the spinstand. Such geometrical configuration and the mechanical limit on the movement along the Y axis set the working area over the lower quadrant of a media (see Figure 1). This prevents the HGA tooling from the collision into the spindle/media when the mechanical parameters of the spinstand or the head geometry are specified incorrectly in the software.

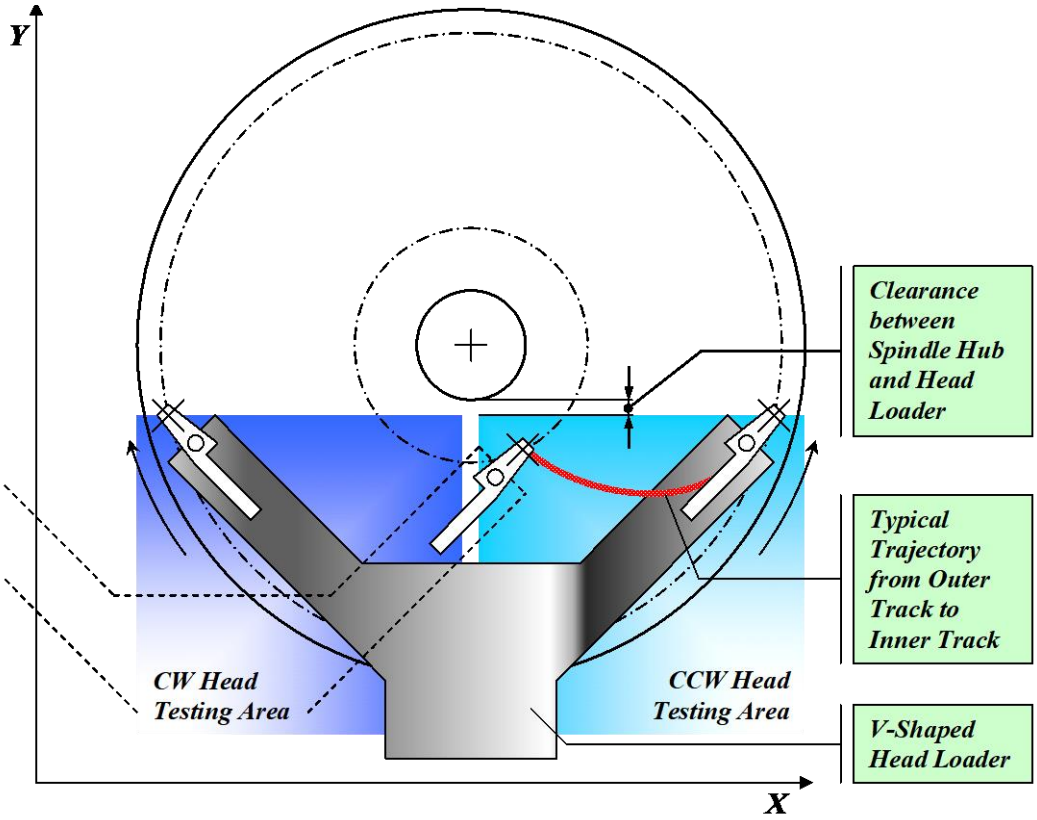


Figure 1: Working Area of V2018 HGA Toolings

SPECIFICATIONS[1]:

Air Bearing Spindle

Motor	Brushless DC, programmable 100 – 20,000 RPM
RPM Jitter	0.005% typical
Acceleration	approx. 2.4 sec (from 0 to 10,000 RPM with 3.5" media)
Interchangeable Spindle Chucks	2.5", and 3.0”/3.5" available Screw clamping
Shroud	Included as standard

Coarse Positioning Mechanism

Actuator Type	X and Y linear motors
Movement Type	Simultaneous dependent XY trajectory movement
Skew Angle Control	Software controlled skew angles
XY Stage Landing Accuracy	< 0.5 um, 0.3 um typical

Micro-Positioning Mechanism

Actuator Type	Piezo element		
Available Piezo Sizes	**18 mm**	**40 mm**	**60 mm**
Usable piezo range (typical)	13 um	20 um	34 um
Piezo-Scales Closed loop Bandwidth (typical)	2.7 kHz	2 kHz	1.6 kHz
Micro-Positioning Encoder Type	Heidenhain glass scale encoder and embedded servo		

[1] Specifications are subject to change without notice

Local Micro-Positioning Accuracy of Glass Scale within Piezo Range	±0.3 nm
Hysteresis	Closed loop system, no hysteresis

Servo Subsystem

(all servo performance parameters are typical values, measured for 7200 RPM, 2.5" product on standard-performing HGAs)

Servo Revision	Servo Revision 8	
Servo Closed loop Bandwidth	**18 mm piezo**	2.5 kHz
	40 mm piezo	1.7 kHz
	60 mm piezo	1.2 kHz
Servo Non-Repeatable Runout	0.19 – 0.35 nm 1σ	
Servo Position Repeatability	±0.35 – ±0.7 nm	
Integral Servo Accuracy within Servo Range	±0.5 nm	
Servo Resolution	0.02 nm	
Damaged Servo Tolerance	**Max. Sequential Damaged Servo Sectors**	2.5% of rev. or 5 *(whichever is smaller)*
	Max. Total Damaged Servo Sectors	10% of rev.
Servo Writing Speed[1] (including capturing)	4 sec per um *(for 13 nm servo pitch)*	
Servo Erase Speed	< 13 ms per track	

Automation System

Gantry Actuator Type	Linear motor
Number of Head Pickers	2

[1] Including capturing with "Regular" servo capturing quality setting

Head Alignment Optical System	USB3 camera, 10 mega pixels
Head Serial Number Recognition Optical System	USB3 camera with microscopic lens on precision mount, 10 mega pixels Optional component
Head Tray Capacity	30 heads
Head Identification Method	Unique HGA tray bar code to identify trays in tray database Optional optical HGA serial number recognition
Head Swapping Time	< 11 sec

Physical

	Spinstand	**Control Box**
Size, W x D x H	40” x 36” x 34”	18” x 18” x 8”
Weight	370 lbs.	36 lbs.

Operational

Environmental	15° C to 40° C, 90% maximum relative humidity, with no condensation, clean room environment
Power Supply	110 VAC ± 15% 50/60 Hz, 3 A approximately 230 VAC ± 15% 50/60 Hz, 2 A approximately
Air Supply	90 PSI minimum, clean dry air
Air Consumption	1.6 scfm
Vacuum Supply	-12.5 PSI minimum
Vacuum Consumption	0.4 scfm (peak) 0.2 scfm (average)
Connection to PC	1x USB2.0 SCB connection 1x USB3.0 integrated USB hub connection