

ADAPTABLE TEST CARRIER FOR STORAGE DEVICES AND METHOD OF TESTING THE SAME

FIELD OF THE INVENTION

The present invention relates to test carriers for electronic storage devices.

- 5 The invention is particularly suited for testing small form factor (SFF) storage devices in a 3.5 inch hard disk drive tester.

BACKGROUND TO THE INVENTION

- The following discussion of the background of the invention is intended to facilitate an understanding of the present invention. However, it should be
10 appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

- Electronic data storage devices have various form factor sizes designed for specific applications such as desktop PC, laptop PC, servers and
15 miscellaneous consumer electronics devices. Common currently used form factors for storage device are in the range of 3.5 inches (8.9 cm), 2.5 inches (6.35 cm), 1.8 inches (4.6 cm) and 1 inch (2.54 cm). However, within each form factor classification, the height of the storage device may vary.

- In a typical storage device manufacturing process, dedicated manufacturing
20 lines and test equipment of specific form factor sizes are required to assemble and test each type of storage device for purposes of quality control. Tests done on the storage device include, but are not limited to, temperature test, electronic circuitry logic test, hard disk memory test, head media test and host interface test.

- 25 One cumbersome problem faced is that different form factor sized storage devices require different testing devices. The test carrier developed by the applicant in WO 2006/115465 may be modified into standard sized testing equipment to test storage device of a smaller form factor size. This allows smaller form factor (SFF) storage devices to be tested in the 3.5 inch testing
30 slots. Modification such as retrofitting the testing equipment removes the

inconvenience of replacing test equipment for storage devices of different form factor size.

However, the operation of the manufacturing lines is required to be interrupted or stopped whenever storage devices of different sizes are to be tested. This is to enable the testing interface to be suitably modified. Each testing machine generally has thousands of testing slots that all must be stopped to modify the testing interface of one or more of the test slots. Such down time of the manufacturing lines contributes to inefficiency in the factory's capital equipment utilization since the production mix can vary day-to-day due to demand fluctuation for each type of storage device. A greater fluctuation in the production mix results in greater interruption and hence a higher inefficiency.

In addition, it is discovered by the applicant that the test carrier in WO 2006/115465 may not be adequately adapted for storage devices of different weight and height. The test carrier further requires an electronic circuitry commonly in the form of Printed Circuit Board Assembly (PCBA) to translate the signals from the storage device interface connector to the tester interface connector. The addition of such independent PCBA interface may introduce electronic signal noises which degrade the interface signal integrity and reliability. It also adds to overall cost for the test carrier.

The object of the present invention is a test carrier to mitigate the aforementioned problems

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the phrase "comprising", "consisting of", and the like, are to be construed as inclusive and not exhaustive.

In accordance with a first aspect of the invention there is a test carrier for testing storage device of form factor smaller than 3.5 inches comprising a carrier base plate having a dimension of a 3.5 inch storage device; an inner wall, joined along the carrier base plate defining a space adapted to house a storage device of form factor less than 3.5 inches; and at least one side guide

pin mounted on the inner wall adapted to receive at least one mounting hole of the storage device of less than 3.5 inches, wherein the storage device is adapted to be held in a testing position by the at least one side guide pin; and the testing position is configured in a orientation to receive an external testing interface, the external testing interface being a testing interface existing for 3.5 inch storage device.

Preferably, the test carrier comprises a top guide plate attached to the inner wall, the top guide plate adapted to receive the storage device of a known maximum height. More preferably, the test carrier also comprises a clamp mounted to the carrier base, the clamp having at least one compressible means to enable the clamp to move from a first compressed position to a second extended position.

Preferably, the carrier base plate includes a weight holder for holding at least one weight.

Preferably, a secondary guide plate may be adapted to be removably attached to the top guide plate.

Preferably, the compression means of the clamp is resiliently biased.

Preferably, the compression means is resiliently biased with at least one spring.

Preferably, the clamp includes a pair of dampers for securing the storage device.

In accordance with a second aspect of the invention there is a method for testing storage devices of different form factor sizes comprising the steps of:

(a) Inserting a storage device of form factor less than 3.5 inches into a test carrier

(b) Securing the storage device by inserting at least one side guide pin of the test carrier into at least one mounting hole of the storage device of form factor less than 3.5 inches Wherein the storage device is inserted in an orientation exposing a host interface connector of the storage device of form factor less

than 3.5 inches to an external testing interface, the external testing interface being a testing interface existing for 3.5 inch storage device.

Preferably, the method comprises the step of contacting an upper face of the storage device of form factor less than 3.5 inches under a top guide plate.

- 5 Preferably, the method comprises the steps of moving a clamp to a first compressed position prior to inserting the storage device of form factor less than 3.5 inches and moving the clamp to a second extended position to contact the storage device of form factor less than 3.5 inches, such that the contact of the clamp and the storage device of form factor less than 3.5 inches
10 dampens vibration occurring during the test.

Preferably, dampening the vibration of the storage device is achieved by the addition of a weight to the test carrier. In this manner, the weight is resiliently held in a weight holder.

- Preferably, a removable secondary guide plate is attached over the top guide
15 plate for securing the storage device of a height less than 15 mm.

Preferably, the clamp is moved from the first compressed position to the second extended position by a spring.

- Preferably, the dampening the vibration of the storage device of form factor less than 3.5 inches is achieved by the addition of a pair of dampers on the
20 clamp.

BRIEF DESCRIPTION OF THE DRAWINGS

The following invention will be described with reference to the following drawings of which:

- Figure 1 depicts the isometric view of a test carrier in accordance with an
25 embodiment of the invention.

Figure 2 depicts the top view of a test carrier in accordance with an embodiment of the invention.

Figure 3 depicts the isometric view of a carrier base in accordance with an embodiment of the invention.

Figure 4a depicts the top isometric view of a clamp in accordance with an embodiment of the invention

Figure 4b depicts the bottom isometric view of a clamp in accordance with an embodiment of the invention

- 5 Figure 5 depicts an embodiment of a test carrier configured for a 2.5 inch storage device with a 15mm height (not to scale)

Figure 6a depicts the secondary guide plate in accordance with an embodiment of the invention.

- 10 Figure 6b depicts the secondary guide plate attached to the test carrier in accordance with an embodiment of the invention

Figure 6c depicts an embodiment of the test carrier configured for a 2.5 inch storage device with a 9mm height (not to scale)

Figure 7a to 7c depicts the steps to load a storage device onto the test carrier.

- 15 Figure 8 depicts a small form factor 2.5 inch storage device with its host interface connector.

DETAILED DESCRIPTION OF THE INVENTION

- 20 It is to be understood that reference to directions and positions (upper, lower, forward, backward, top, bottom, left right etc.) are to be understood in the general context of the typical operational orientation of the invention as defined in the drawings, specifically Figure 2.

In accordance with an embodiment of the invention there is provided a test carrier 10 as shown in Figures 1 and 2. The test carrier 10 comprises a carrier base 11, a clamp 14 and weight 20.

- 25 Carrier base 11 comprises carrier base plate 12, clamp holder assembly 22 and weight holder 16 integrally moulded together. The dimensions of the carrier base plate 12 are roughly the same as that of a 3.5 inch testing slot. However, the right side edge of the carrier base plate 12 is shorter for purposes of adapting a storage device 60 of smaller form factor. Common form factor storage devices in the industry include storage devices of form

factor 2.5 inch, 1.8 inch and 1 inch. Part way along a first side of the base plate 12, the flat rectangular sheet has a sectioned portion defined by a rear guide wall 13, the sectioned portion having; a clamp 14, a wedge shaped wall 15 and four walls defining a cubed shaped void or recess. The clamp 14 is positioned at a space defined roughly around the central part of the sectioned portion. One of the four walls defining the cubed shaped void or recess abuts the clamp 14. Two of the remaining four walls meet at right angles forming outer corner walls sitting in planes perpendicular to the plane of the carrier base plate 12. The two of the remaining four walls and the plane of the carrier base plate 12 forms three mutually perpendicular intersecting flat surfaces at a corner of the carrier base plate 12 (the left rear corner as defined in Figure 2). The final of the four walls defining the cubed shaped void or recess abuts a weight holder 16. The weight holder 16 comprises a continuation of one of the walls forming the corner of the carrier base plate 12 and extends along one of the longitudinal sides of the carrier base plate 12 and ends beyond the exposed short side of the carrier base plate 12. An inner wall 17 runs parallel to the wall extending along one of the longitudinal sides of the carrier base plate 12 and ends beyond the exposed short side of the carrier base plate 12. The parallel walls are joined at right angles by an end wall 18 hanging beyond the carrier base plate 12. The weight holder 16 is adapted to house a weight 20 as described below. A top guide plate 21 extends substantially perpendicular to the inner wall 17 in a plane substantially parallel to the carrier base plate 12, At least two side guide pins 26 extrude from the inner wall 17 adjacent the carrier base plate 12. The space defined by the carrier base plate 12, the rear guide wall 13 and the inner wall 17 forms a bottom plate 24 adapted to house a storage device for testing. Figure 3 depicts the carrier base 11 (test carrier 10 with the clamp 14 and weight 20 removed). The weight holder 16 comprises flaps 54a, 54b. When weight(s) 20 is inserted into the weight holder 16, it pushes flaps 54a, 54b against the outer wall parallel to the inner wall 17. Upon the insertion of the weight(s) 20, flaps 54a, 54b are enabled by a resilient mechanism such as deformable fingers to move away from the outer side wall 56 and thereby exerting a suitable pressure against the weight 20 to secure it in place. Additional weights 20 may be added to the weight holder 16 to provide the desired damping weight for the test carrier 10.

The purpose of weights 20 is to minimize the vibration of the test carrier 10 which could be introduced by the test system's cooling fans and other moving parts of the tester. Such external source of vibrations could degrade the performance of the storage device under test and cause a misdiagnosis of test – for example, diagnosing a perfectly normal storage device 60 as a false failure.

A clamp holder assembly 22 is depicted in the sectioned portion of Figure 3 comprising,

a slider guide 30a, mounted onto the carrier base plate 12 that forms a C shaped channel, a second slider guide 30b mounted opposing, on one of the four walls defining the cubed shaped recess forming a shelf that extends perpendicular to the wall such that the wall and the shelf form an opposing C shaped channel to house the clamp 14 when it is slid into place. The position of the slider guides 30a, 30b are biased to the rear portion of the carrier base plate 12 within the sectioned portion. The slider guide 30a is an L-shaped flange protruding from carrier base plate 12. At the base of the L-shaped flange connected to the carrier base plate is a lengthwise rail 31a. The shelf of the second slider guide 30b protrudes substantially parallel to a second lengthwise rail 31b. Rail 31b is substantially parallel to rail 31a.

With reference to figure 3 and 4 Clamp 14 is removably attached to slider guides 30a, 30b via rail shoulders 40a, 40b. Rail shoulders 40a, 40b are adapted to fit rails 31a, 31b. The rail shoulders 40a, 40b and rails 31a, 31b are designed as would be known to the person skilled in the art to provide an appropriate sliding contact between the rail shoulders 40a, 40b and rails 31a, 31b and will not be further elaborated here.

When the clamp 14 is slid into place guided by the rails 31a and 31b the movement of the clamp 14 is constrained between a rear end bracket 42 and an opposed forward stop pin 43. The movement of the clamp 14 is approximately in a perpendicular direction from a rear wall(not shown). The rear end bracket 42 is affixed to the rear wall 36. The rear end bracket 42 is adapted to accommodate an end of a spring 44. The spring 44 extends into and affixed to the clamp 14 within a connector recess 45. The connector

recess 45 as shown in Figure 4b is connected on an underside of the clamp 14. A second rectangular recess 46 situated on the opposing side to the connector recess 45 is adapted to accommodate the forward stop pin 43.

The clamp 14 is adapted to move from a first compressed position to a second extended position. At the first compressed position, the outer wall 48a of the rectangular recess 46 contacts the forward stop pin 43 and spring 44 is compressed. At the second extended position, the inner wall 48b of the rectangular recess 46 contacts the forward stop pin 43 and spring 44 is extended relative to the spring 44 compressed position.

- 10 The positioning of the clamp 14 to its first compressed position is facilitated by a round recess 36. The round recess 36 is adapted for a robotic arm to retract the clamp 14 towards the first compressed position.

Clamp 14 further comprises dampers 52. The dampers 52 are to damp any force when the clamp 14 is in use such that contact with a storage device 60 loaded onto the test carrier 10 may prevent excessive force from being exerted on the storage device 60. The dampers 52 are further adapted to contact the storage device 60 such that it reduces vibration of the storage device during testing. The dampers 52 are made of soft Polyurethane material.

- 20 The bottom plate 24 has a length and width dimension slightly smaller than that of a storage device 60 of small form factor devices smaller than 3.5 inches. The bottom plate 24 further comprises a plurality of air openings 50 to provide ventilation.

Referring to figure 5, when in use a storage device 60 is placed onto the bottom plate 24. In the current example a 2.5 inch storage device is placed on the bottom plate 24. The storage device is placed such that it extends beyond the bottom plate 24 to provide adequate access between the storage device host interface connector 64 and the existing testing interface for a 3.5 inch storage device housed within the testing equipment. The two side guide pins 26 are positioned substantially near the bottom end of the inner side wall 17 and are adapted to fit into side mounting holes 62 of a storage device 60.

Generally a storage device 60 will have at least 4 side mounting holes 62, 2 each on opposing sides. The location of the side mounting holes 62 is determined by the accepted industry standard and may vary for different form factor sized storage devices. The mounting pins are adapted to fit into side mounting holes for the accepted industry standard location of the side mounting holes of a particular storage device to be tested.

The top guide plate 21 protrudes from upper middle section of the inner side wall 17. Two protrusions 17a, 17b, suitably spaced apart, extend throughout the breadth of the top guide plate 21 at the underside of the same. The height of the top guide plate 21 from the bottom plate 24 is determined by the height of the tallest storage device 60 to be used for testing, typically 15mm for the 2.5 inch storage device of this embodiment. For testing a storage device 60 with a height less than the maximum for example that depicted in Figure 6, the top guide plate 21 may have a secondary guide plate 80 slipped over the top guide plate 21. A rectangular slot 19 on the top guide plate 21 adjacent the inner side wall 17 is adapted for receiving a clip 82 for attaching the secondary guide plate 80 over the top guide plate 21. The secondary guide plate 80 may be removably attached onto the top guide plate 21 by means of the clip 82. The secondary guide plate 80 is similar in shape to the top guide plate 16 apart for a hollow body 84 adapted to slide over the top guide plate 21 (see Figure 6b). The clip 82 on the secondary guide plate 80 clips onto the rectangular slot 19 of the top guide plate 21 so that it is securely attached.

Figure 6c illustrates the use of the secondary guide plate 80 with a 9mm 2.5inch storage device loaded onto the test carrier 10.

The test carrier 10 will now be described in relation to figure 7 in the context of an operational example.

To test a storage device 60 using the test carrier 10, a storage device 60 must first be loaded onto the test carrier 10. The loading is either performed manually by human operator or by a robotic machine. In the context of this example:

(a) the loading and unloading steps are performed using a robotic machine comprising robotic arms (not shown).

(b) The weight holder 16 is suitably adjusted with weights 20 to counter balance the weight of the storage device 60 and to damp any undesired vibrations arising due to the testing. Typically, weights 20 are in pieces 50-gram weight, and the weight holder can be loaded up to 6 pieces of weights 20 (equivalent to 300 grams)

In accordance with figure 7a, Step 72, positioning the clamp 14 to its first compressed position using the robotic arm.

10 In accordance with Figure 7b, step 74, the storage device 60 is inserted from the exposed side of the test carrier 10 using robotic arms at step 74. This may be achieved using computer control means to manipulate the robotic arms which is known to a person skilled in the art. During insertion, the orientation of the storage device 60 is such that the host interface connector
15 64 of the storage device 60 faces an exposed side 65 adjacent the inner side wall 17 of the test carrier 10. When the storage device 60 is positioned within the test carrier 10, it contacts the top guide plate 21, the inner side wall 17 the rear guide wall 13 and the bottom plate 24 where it is designed to hang over and extend beyond the bottom plate 24, To ensure that the storage device 60
20 is secured to the test carrier 10 during testing so as to prevent any unnecessary movement and vibration, the two side guide pins 26 of the test carrier 10 are inserted into the two side mounting holes 62 at the side of the storage device 60 contacting the inner side wall 17. The storage device 60 is then fully inserted into the test carrier 10 as shown in Figure 7b.

25 In accordance with Figure 7c, step 76, the clamp 14 is released such that the spring 44 extends and pushes the clamp 14 forward towards the storage device 60. The dampers 52 are pushed against the rear wall 63 of the storage device 60 as shown in Figure 7c. The stiffness of the spring 44 and the softness of the dampers 52 can be balanced and optimized to provide firm
30 clamping on the storage device 60 with optimal vibration damping effect. To determine the optimal vibration damping effect, measurement of the storage device's vibration energy when it is running in the test carrier are obtained.

Subsequently these measurements are used to obtain a vibration peak power spectrum via any method known to a person skilled in the art. The optimal is achieved when the vibration peak power spectrum is lowest. The two side guide pins 26 inserted into the mounting holes 62 of the storage device's 60 prevent the storage device 60 from moving forward. This position secures the storage device 60 to the test carrier 10 for testing.

With the storage device 60 loaded in the test carrier 10, the storage device 60 is ready to be tested in a standard 3.5 inch storage device tester. The standard 3.5inch storage device tester is connected to the host interface connector 64 of the storage device 60.

Upon the completion of testing the storage device 60, the storage device 60 is unloaded by disconnecting the standard 3.5 inch storage device tester from the host interface connector 64. Step 72 is then repeated to push the clamp 14 to its first compressed position. The storage device 60 is then removed by robotic arms. The software program within the tester performs a check to determine if the next storage device 60 is of the same height and/or form factor size. If the storage device 60 is of a different height (say 9mm) of the same form factor size of 2.5 inches, the robotic machine automatically inserts the secondary guide plate 80 onto the top guide plate 21 before steps 72 to 76 are applied. However, if the next storage device 60 is a 3.5 inch storage device, the robotic machine will connect the 3.5 inch storage device tester to the host interface connector 64 bypassing the need of test carrier 10.

It is to be noted that during the process of unloading the tested storage device 60 and loading the next untested storage device, there is no need to interrupt or stop the manufacturing line to retrofit, reorientate, or replace the storage device tester. This is due to the host interface connector 64 of any 2.5 inch SATA or SAS storage device 60 being placed in the same orientation as that used to test a 3.5 inch storage device. The test carrier having a bottom plate 24 adapted to allow the host interface connector 64 of a small form factor storage device to extend beyond the base plate and interface with the storage device tester used for 3.5 inch storage devices. The test carrier 10 is effectively recognized as a standard 3.5 inch storage device 60 by the tester,

regardless of form factor size, height, and weight. This results in considerable time savings.

It should be appreciated by the person skilled in the art that the invention is not limited to the embodiments described above. In particular, the following

5 modifications may be made without departing from the scope of the invention:

- The test carrier 10 can be adapted to test other smaller SFF storage devices other than the 2.5 inch form factor. This involves adding and/or repositioning the side guide pins 26 to the industry standards for the mounting holes 62 of the smaller SFF storage device 60 and/or
10 adjusting the top guide plate 21 and secondary guide plate 80 to the desired height.

- The positioning of the clamp 14 between its first and second position may also be performed by a human being in replacement to the robotic arm. Specifically, a square recess 47 is adapted for a human finger to
15 retract the clamp 14 to its first compressed position.

- The robotic machine may be configured to unload and reload the different sized storage devices 60 based on the quantity of each type of storage device 60. For example, upon completion of the testing of the requisite number of 2.5 inches storage devices 60, the robotic machine
20 automatically unloads the 2.5 inches storage device 60 and loads the test carrier 10 with the new batch of 2.5 inches storage device 60 of a different height.

- The secondary guide plate 80 may be further configured to other heights other than 15mm or 9mm as described in the embodiment.

- The host interface connector may be either the SATA or SAS interface.
25

CLAIMS

1. A test carrier for storage devices comprising:

a carrier base having a dimension of a 3.5 inch storage device;

an inner wall, joined along the carrier base defining a space adapted to house a storage device of form factor less than 3.5 inches; and

at least one side guide pin mounted on the inner wall adapted to receive at least one mounting hole of the storage device of less than 3.5 inches,

wherein the storage device is adapted to be held in a testing position by the at least one side guide pin; and the testing position is configured in a orientation to receive an external testing interface, the external testing interface being a testing interface existing for 3.5 inch storage device.

2. The test carrier according to claim 1, further comprising a top guide plate attached to the inner wall, the top guide plate adapted to receive the storage device of a known maximum height;

3. The test carrier according to claim 1 or 2 further comprising a clamp mounted to the carrier base, the clamp having at least one compressible means to enable the clamp to move from a first compressed position to a second extended position;

4. The test carrier according to any one of claims 1 to 3, wherein the carrier base plate includes a weight holder for holding at least one weight,

5. The test carrier according to any one of claim 2 to 4, further comprising a secondary guide plate adapted to be removably attached to the top guide plate.

6. The test carrier according to any one of claims 3 to 5, wherein the compression means of the clamp is resiliently biased.

7. The test carrier according to claim 6 wherein the compression means is resiliently biased with at least one spring.

8. The test carrier according to any one of claims 3 to 7, wherein the clamp includes a pair of dampers for securing the storage device.

9. A method for testing storage devices of different form factor sizes comprising the steps of:

5 (a) Inserting a storage device of form factor less than 3.5 inches into a test carrier

(b) Securing the storage device by inserting at least one side guide pin of the test carrier into at least one mounting hole of the storage device of form factor less than 3.5 inches wherein the storage device is inserted in an orientation
10 exposing a host interface connector of the storage device of form factor less than 3.5 inches to an external testing interface, the external testing interface being a testing interface existing for 3.5 inch storage device.

10. The method of claim 9 further comprising the step of contacting an upper face of the storage device of form factor less than 3.5 inches under a
15 top guide plate.

11. The method of claim 9 or 10 further comprising the steps of moving a clamp to a first compressed position prior to inserting the storage device of form factor less than 3.5 inches and moving the clamp to a second extended position to contact the storage device of form factor less than 3.5 inches, such
20 that the contact of the clamp and the storage device of form factor less than 3.5 inches dampens vibration occurring during the test.

12. The method according to claim 11, further comprising dampening the vibration of the storage device by the addition of a weight to the test carrier.

13 The method of claim 12 wherein the weight is resiliently held in a weight
25 holder.

14. The method according to claim 10, comprising the step of attaching a removable secondary guide plate over the top guide plate for securing the storage device of a height less than 15 mm.

15. The method according to any one of claims 11 to 14, wherein the clamp is moved from the first compressed position to the second extended position by a spring.

16. The method according to any one of claims 11 to 15, further comprising
5 dampening the vibration of the storage device of form factor less than 3.5 inches by addition of a pair of dampers on the clamp.