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Design Guide
Measurement Systems

Versi-Traq

Clamshell Bed-of-Nails Test Fixture

Version 4.4.2

Automatiq Measurement Systems LLC
552 Acton Road
Columbus OH 43214 ▪ USA
Voice ▪ 800-346-3938 614-431-2667
Contact@AutomatiqSystems.com www.AutomatiqSystems.com

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Chapter 1 Overview

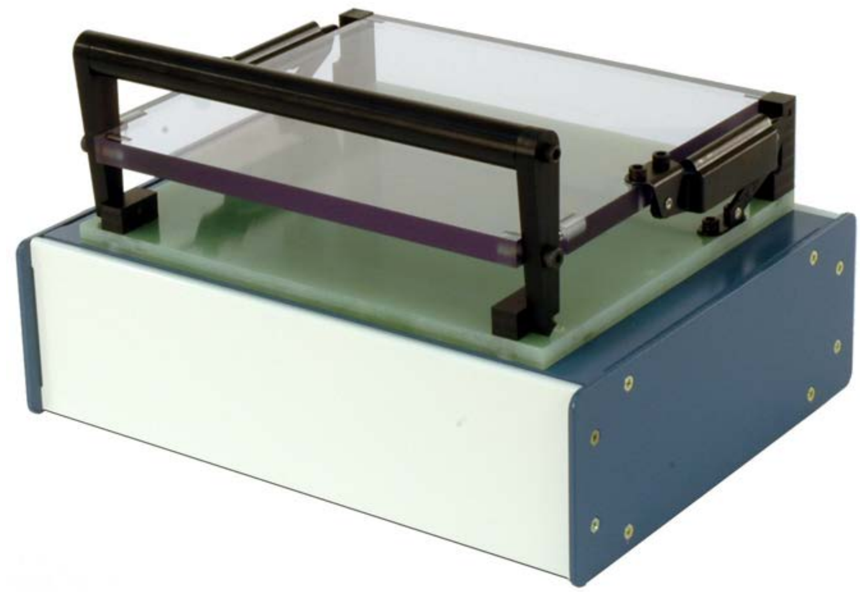
This Design Guide covers the following topics:

- Introduction to the Versi-Traq Test Fixture
- Design for Test
- Make or Buy
- Design of the Versi-Traq Test Fixture
- Fabrication & Assembly of the Versi-Traq Test Fixture
- Wiring the Versi-Traq Test Fixture

This Design Guide was written for

- Engineers and Designers who are considering using the Versi-Traq Test Fixture (see Chapter 1)
- Engineers and Designers who are designing circuit boards that will be tested with a Versi-Traq Test Fixture (see Chapter 2)
- Engineers and Designers who are deciding whether to make their own modifications to an unmodified Versi-Traq Test Fixture or to buy a ready-to-wire Versi-Traq Test Fixture (see Chapter 3)
- Engineers and Designers who are designing a Versi-Traq Test Fixture for a circuit board (see Chapter 4)
- Machinists who are modifying a Versi-Traq Test Fixture (see Chapter 5)
- Engineers and Technicians who are wiring a Versi-Traq Test Fixture (see Chapter 6)

Versi-Traq Test Fixture



The Versi-Traq Test Fixture is an inexpensive Clamshell Bed-of-Nails test fixture.

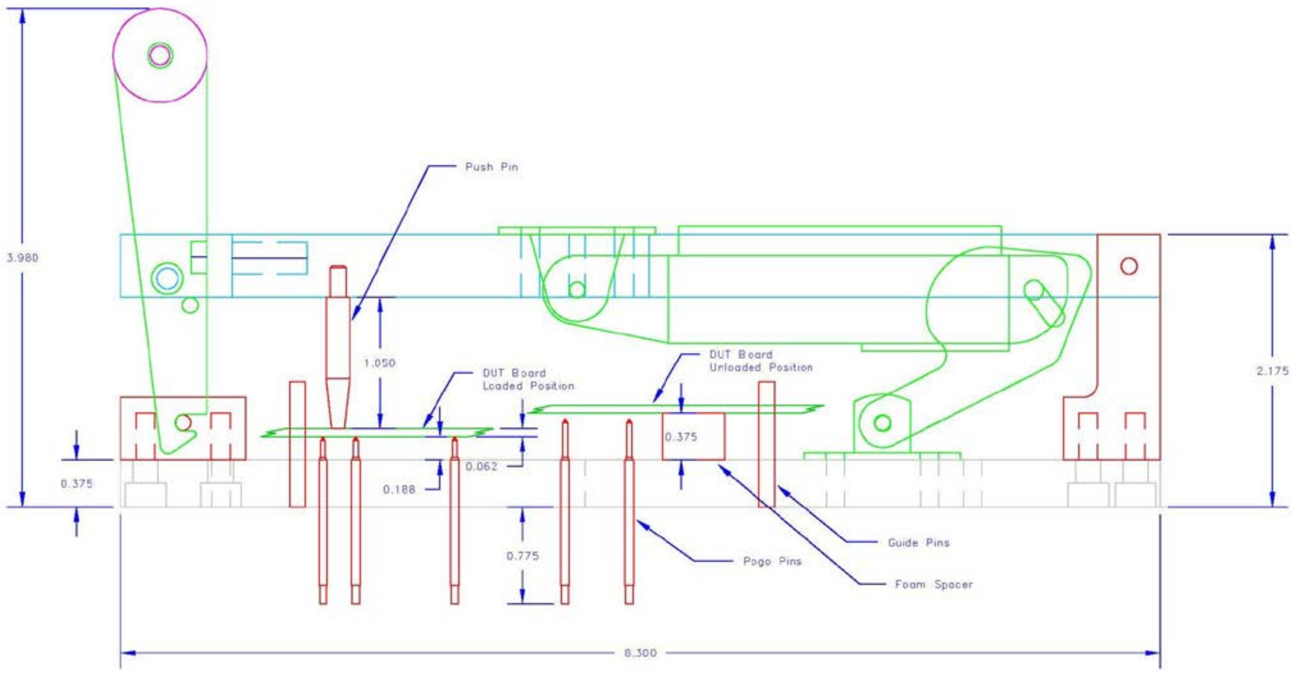
Bed-of-Nails means that test points on the board or assembly are contacted with spring pin contacts usually called pogo pins. Pogo pins are relatively inexpensive and can provide up to a million test cycles before they need to be replaced.

The board must be pushed down onto the pogo pins to make contact. Clamshell fixtures use a hinged top cover with push down pins to push the board down on the pogo pins. The top cover then latches closed.

The Versi-Traq Test Fixture is inexpensive because of its simple and elegant design. It does not require expensive structural frames, complicated latch mechanisms, or a large size to accomplish its function.

Design & Operation

The following is a side view of the Versi-Traq Test Fixture that shows its operation.



The fixture operates as follows:

- The Top Cover is unlatched and hinged up out of the way. The Lid Lifters hold the Top Cover in the open position.
- The Device Under Test (circuit board) is loaded using the Guide Pins for location. The circuit board may be supported in the unloaded position by the Pogo Pins or by several Foam Spacers.
- The Top Cover is rotated down and latched. As it swings down, a number of Push Down Pins push the circuit board down to the loaded position. In the loaded position, the Pogo Pins compress and make contact with the test points on the circuit board.

The key components are:

Probe Plate: The Probe Plate is made of 0.375” thick FR4 and provides the mechanical structure of the fixture. It also provides the support for the Pogo Pins and Guide Pins.

Pogo Pin Sockets: The Pogo Pin Sockets are pressed into accurately drilled holes in the Probe Plate. They are usually provided with a solder cup on the bottom for wiring into the test system.

Pogo Pins: The individual Pogo Pins are pushed into the Pogo Pin Sockets from the top and held by friction. They can be replaced if damaged or worn by pulling them out and pushing in a new pin. The tip of the pin has a number of options to match the test point that is being probed.

Guide Pins: The Guide Pins are precision ground hardened steel pins mounted in accurately drilled holes in the Probe Plate. The Guide Pins locate the circuit board and keep it from moving horizontally as it is pushed down by the Push Down Pins. There are usually two Primary Guide Pins that provide the location. Additional undersized Secondary Guide Pins may be provided to prevent the circuit board from being loaded incorrectly.

Top Cover: The Top Cover is made of 0.500" thick clear Polycarbonate. It is hinged at the back and has a latch at the front.

Push Down Pins: The Push Down Pins are black Acetal and are press fitted into holes in the Top Cover. They push the circuit board down to the loaded position when the Top Cover is rotated down and latched.

Foam Spacer: Foam Spacers are sometimes necessary to keep the circuit board stable while it is being pushed down to the loaded position.

Later chapters will provide more details and options for designing and fabricating a Test Fixture.

Associated Documentation

The following Versi-Traq documents are available from the Automatiq website (https://www.AutomatiqSystems.com/Documentation.html)

SMD-00031	Versi-Traq Datasheet
SMD-00032	Versi-Traq Components Datasheet
SMD-00030	Request for Quote form
DOC-00038	Versi-Traq Design Guide (this document)
DOC-00039	Versi-Traq Documentation Package

The Versi-Traq Documentation Package provides outline drawings of the Probe Plate, Top Cover, Mounting Cutouts, and Base Enclosures that can be modified to show the necessary holes and cutouts for the customized Test Fixture. The drawings are provided in AutoCAD and PDF format. See the included ReadMe file for a directory.

Chapter 2 Design for Test

While the electrical and mechanical requirements of a circuit board may put limits on the accommodations for testing, it is important to understand the testing requirements and tradeoffs during the board design and layout.

The following sections will discuss the testing requirements and tradeoffs for Clamshell Bed-of-Nails test fixtures in general and those specific to the Versi-Traq Test Fixture.

Probe Points

Single Side Probing

Design circuit boards for single side probing.

All Bed-of-Nails test fixtures have serious difficulty probing two sides of the test board because of the difficulty of mounting pogo pins on the top side of the fixture and locating them accurately.

The Versi-Traq Test Fixture and clamshell fixtures in general are unable to probe the top side of the circuit board because the curving path of the top cover of the fixture would cause the tip of the pogo pin to move to the back as it pushes down. This would bend and destroy the pogo pin.

Normally, the board is probed from the bottom side. There is usually more space on the bottom for probe points and if there are bottom side components, they are usually low height and will not interfere with the probe plate.

In some cases it makes sense to locate the probe points on the top side and mount the board in the fixture top-side-down. If this option is taken, make sure that switches and lights can be accessed during the test if necessary.

Probe Point Spacing

Locate Probe Points at least 0.100” apart if possible.

The standard pogo pin is designed to be mounted on at least 0.100” centers. This sized pin is quite rugged and inexpensive.

Pins that can be mounted on 0.075” centers are only slightly less rugged and slightly more expensive. They are quite suitable for all test fixtures.

Pins that can be mounted on 0.050” centers are much less rugged and significantly more expensive. Hitting these pins with the board while loading or unloading is likely to bend or break them. Avoid these pins if at all possible and use them sparingly if you must.

Probe Point Size

Make Probe Points at least 0.030" diameter if possible.

The minimum acceptable probe point diameter is determined by the tolerance build up in the test fixture probe plate and the circuit board accuracy.

Guide pins are usually sized 0.004" to 0.008" under the mounting hole size and the mounting hole diameter is usually specified with a ±0.003" tolerance. This all adds up to a positioning tolerance of the circuit board of about ±0.007".

The drilling tolerance on a digital readout mill or CNC drill or router should be set to ±0.001" for both the guide pins and the pogo pin socket holes. While the drill position can be set to high accuracy, the drill bit tends to wander some when it starts drilling. This causes a small error in the starting position but because of the drill geometry, it can cause the hole to be drilled out of plumb. This can contribute ±0.003 or so to the pogo pin contact position. In addition, the mounting of the pogo pin socket can contribute another ±0.001" or so error in the contact position. All together this could result in a ±0.004 error in the position of the pogo pin contact point.

This gives a cumulative error of about ±0.011". A 0.030" diameter pad gives at least a safety margin of 0.004". In practice, 0.025" or even 0.020" diameter pads can be used but they require extra care in machining, tight guide pins, and accurate circuit boards.

Number of Probe Points

Keep the total number of Probe Points less than 100 if possible.

The standard pogo pin is designed to have about 5 oz of force at the loaded position. This results in a total force of a bit over 30 pounds for 100 pins. Because of the lever action of the top cover this is reduced to 20 pounds or so at the front of the top cover. This is near the limit of what an operator can be expected to close. Low force pins can be special ordered with about 3 oz. of force at the loaded position. This can reduce the total force if more than 100 pins are required.

In addition, large numbers of probe points requires large numbers of push down pins to prevent the board from being distorted when it is pushed down. On high density boards this may present a problem in finding enough places on the top of the board for the push down pins.

Probing Vias

Vias can be probed.

Probe points with holes (often vias) can be probed. They are usually probed with a chisel point pogo pin. Make sure the pogo pin head will not go through the hole. Also make sure that the probe point (via) is not solder masked on the side where they are probed.

Probing Connectors

Probing the back of Through-Hole connectors is usually okay.

Probing the back side of a through-hole connector is usually acceptable. If necessary special pogo pin heads with an insulator ring can prevent contact with the pad and limit contact to the connector pin to ensure that it is present.

It is also sometimes possible to probe the contact side of connectors that are mounted on the bottom side (as mounted in the fixture). However, an auxiliary probe plate may be needed. See the section on probe planes for more details.

Probing top side SMT connectors is usually not possible. Probe points should be provided on the bottom in this case.

Probing Components

Avoid probing SMT component leads if possible.

While it is sometimes necessary, probing a SMT component lead usually means probing a sloped surface which can put side force on the pogo pin and sometimes cause it to slip off the pad. Spear point pogo pins dig in and avoid slipping on all but the steepest surfaces. Try to probe the flatter surfaces.

Probing the end of a through-hole lead with a crown head pogo pin is usually not a problem unless it is trimmed long or bent before soldering.

Conformal Coating

Avoid probing through a Conformal Coating.

Conformal Coatings will prevent pogo pins from making contact with the probe point. While spear points can be used, they will still be marginally reliable and will damage the Conformal Coating. Probe points can be masked or the board can be tested before Conformal Coating.

Probing Mounting Holes

Mounting holes that are used for location cannot be probed.

Sometimes mounting holes are used for electrical contacts (grounds etc.). It is usually not possible to probe a mounting hole pad that is being used for a guide pin. There is not enough room for a pogo pin and the guide pin does not make good electrical contact. If possible, use other mounting holes for guide pins so there is room to install a pogo pin. Otherwise, provide a probe point near the mounting hole that can be probed.

No Clean

Take care when probing No Clean boards.

No Clean boards (boards with deactivated flux remaining) present difficulties. First, the flux layer may be difficult to probe through the flux and make good contact. Additionally, the flux will build up on the pogo pins (particularly crown points). This will require cleaning or replacing the pogo pins to maintain reliable contact.

Positioning & Push Down

Guide Pins

Use Guide Pins in mounting holes or tooling holes if possible.

The simplest and most accurate circuit board positioning is done by using guide pins into mounting or special tooling holes. The most accurate positioning will come from using two guide pins on holes located on diagonally opposite corners of the board.

If possible specify the holes to be non-plated through (as they are more accurate). Specify the diameter to be a standard drill size. Specify the tolerance to be +0.003”, -0.000” if possible (the standard tolerance is usually ±0.003”).

Secondary Guide Pins

Use Secondary Guide Pins to prevent improper loading if possible.

Use secondary guide pins (pins that are much smaller than the hole) to prevent the circuit board from being loaded incorrectly. Locate holes that are not symmetrical so the circuit board cannot be loaded if it is oriented incorrectly.

Edge Positioning

Use Edge Positioning only if mounting holes or tooling holes are not available.

Circuit boards can be located from the edges if necessary. However, edge routing is a secondary operation when fabricating boards and is not usually as accurate as holes. On a rectangular board, use two pins on each side of the long dimension and a single pin at each of the short dimensions (six in total). Try to avoid areas where the board has been scored or perforated and broken since the repeatability is poor.

If edge positioning is used, avoid very small probe points.

Push Down Pins

Make sure there is enough space for Push Down Pins.

Circuit boards require push down pins near each corner and at least one push down pin for every ten pogo pins. Push down pins require a landing space clear of components as well as extra space to the front of the board as they slide back as the top cover rotates down.

Attempts to push on components may break the component or its solder joint and may have poor positioning accuracy because of variations in component heights.

Thin boards may need additional push down pins to prevent bending the board and damaging components or solder joints.

Clearance & Access

Bottom Components

Limit bottom components to 0.170” high if possible.

Components on the bottom of the board (as mounted in the test fixture) are limited to about 0.170" high (with some tolerance). Otherwise, the Versi-Traq Probe Plate will need to be machined out to clear them. This is not difficult but adds cost to the fixture.

Top Components

Limit top components to 1.000” if possible.

Components on the top of the board (as mounted in the test fixture) are limited to about 1.000” high (with some tolerance). Otherwise, the Versi-Traq Top Cover will need to be machined out to clear them. This is not difficult but adds cost to the fixture.

Access

Locate access points on the top of the circuit board if possible.

Circuit boards may require access to lights, switches, jumpers, or adjustments during the test. These points should be located on the top of the board (as mounted in the test fixture) so they can be seen through the top cover or accessed through cutouts in the top cover.

If these access points must be on the bottom, consider locating them to a board edge where they may be accessed from the side.

Lights on the bottom of the board can be provided with remote viewing via a fiber optic cable if necessary. It is not as convenient to view and will add cost to the fixture.

A mechanism to make adjustments on the bottom of the board can be provided but it adds significant cost to the fixture.

Switches and jumpers can be simulated with connections to external switches or relays but they do not test the operation of the switches. The boards can be removed and switches or jumpers adjusted but it takes additional time for the test.

Safety

Safety Skirts

Provide Safety Skirts for High Voltage Test Fixtures.

If the Board-Under-Test has voltages higher than about 48 volts, Safety Skirts should be provided to prevent operators from coming in contact with dangerous voltages.

Interlock Switch

Provide an Interlock Switch for High Voltage Test Fixtures.

If the Board-Under-Test has voltages higher than about 48 volts, an Interlock Switch should be provided to disable high voltages when the top cover is not closed and locked.

Chapter 3 Make or Buy

Automatiq can provide the unmodified Versi-Traq Test Fixture and the various components necessary for customizing the Test Fixture to test a circuit board. We also provide design and fabrication information for accomplishing the project (see the following chapters).

However, most customers prefer to have Automatiq provide a ready-to-wire fixture that has the Pogo Pins & Sockets, Guide Pins, Foam Spacers, and Push Down Pins installed, the Probe Points identified on the bottom, and the Test Fixture assembled and mounted on a Base Enclosure.

Please fill out the Request for Quote form on our web site for a quote (usually in less than a day). If there are complicated issues, a sketch or photo may be required for the quote.

After you have received the quote, we will need the following in order to proceed:

- Purchase Order
- Gerber files for the board
- Test Point List with way to relate Test Points to the Gerbers (silkscreen layer, markup, etc.)
- Sample Board populated as it will be tested (to be returned)

DOC-00047 provides more details on what is needed to get started.

Delivery is usually 2 weeks or less after receipt of the PO, documentation, and sample board.

Advantages of making the modifications yourself:

- May be less expensive
- May be faster
- More flexible design

Advantages of ready-to-wire from Automatiq:

- No design or fabrication resources required
- Usually is less expensive when all costs are considered
- Often is faster than doing it yourself
- Do not need extensive tooling and supplies
- Do not need to learn a lot of design issues
- Can take advantage of Automatiq's experience and expertise
- Automatiq's CNC routing and drilling is accurate and low cost
- Automatiq has standard and custom software tools to make the job faster and more accurate

Chapter 4 Design

This chapter describes the design issues required to design the customization of the Versi-Traq Test Fixture to probe a board.

Required Documentation & Tools

A number of documents and tools are necessary or helpful for the design process.

Circuit Board Requirements

There are several circuit board specific requirements:

- **Gerbers:** Gerbers for the circuit board including the probe point positions, mechanical outline, and drill diameters.
- **Test Point List:** A list of test points and a way to relate the test points to the Gerbers.
- **Sample Board:** A sample board populated as it will be tested.

General Requirements

There are a number general purpose tools that are necessary or helpful:

- **CAD Drafting:** A CAD drafting package of some sort is required to create mechanical drawings. If blank drawings provided by Automatiq are going to be used as a template, the CAD software will need to be able to read AutoCAD files.
- **Gerber Viewer:** A Gerber Viewer is required to view the Gerber files and locate various points on the board.
- **Digital Calipers:** A set of 6” digital calipers will be extremely useful.
- **Hole Gauges:** A set of Pin Gauges for diameters from about 0.010” to about 0.250” is the only practical way to measure the diameter of holes in the circuit board. They are also useful in measuring “as drilled” hole diameters during fabrication. Most mill supply houses have relatively inexpensive imported sets for about $150.

Drill List

Origin & Orientation

The Gerber files often have the origin located at a mounting hole of the board or located some distance from the board. Occasionally some layers in the Gerbers will not have the same origin. The circuit board in the Gerber files should be oriented as it will be mounted in the Test Fixture, with the origin at the lower left corner of the board. This includes if the board will be mounted top-side-down. If the origin and orientation of the Gerbers cannot be changed using the Gerber file viewer, the coordinates will need to be transformed in a spreadsheet.

Test Points

It is difficult to add Test Points to a Test Fixture after it has been fabricated and very difficult after it has been wired. On the other hand, drilling extra holes costs almost nothing.

For that reason, we recommend that all potential Test Points are drilled with unpopulated holes. It is quite easy to install a Socket and Pogo Pin in the previously drilled unpopulated hole if the Test Point is required at a later date. Potential Test Points can be specified as “Hole Only”. Potential Test Points can alternatively be specified as “Pogo Pin Socket Only”.

X	Y	Name	X Flipped	Y Shifted
2.0000	-0.2500	Corner	0.2500	0.0000
0.2500	-0.2500	Corner	2.0000	0.0000
0.2500	2.5000	Corner	2.0000	2.7500
0.5000	2.7500	Corner	1.7500	3.0000
2.2500	2.7500	Corner	0.0000	3.0000
2.2500	0.0000	Corner	0.0000	0.2500
1.7500	0.2500	Mount	0.5000	0.5000
0.7500	2.2500	Mount	1.5000	2.5000
0.5000	0.0000	Mount	1.7500	0.2500
2.0000	2.2500	Mount	0.2500	2.5000
1.5000	0.6000	TP1	0.7500	0.8500
1.9000	1.3750	TP2	0.3500	1.6250
1.3750	2.2500	TP3	0.8750	2.5000
1.9500	0.9000	TP4	0.3000	1.1500
1.7500	2.0000	TP5	0.5000	2.2500
1.2000	1.4000	TP6	1.0500	1.6500
1.7250	2.5000	TP7	0.5250	2.7500
0.5000	0.7500	J1.1	1.7500	1.0000
0.5000	0.8500	J1.2	1.7500	1.1000
0.5000	0.9500	J1.3	1.7500	1.2000

Record Hole Positions

The first step in generating a Drill List is to capture the positions of the Test Points, the board corners, and any mounting or tooling holes.

The Test Point List should include some way to relate the Test Points to the Gerbers. The Test Point List could have the coordinates of each Test Point, or the Test Point List could have named Test Points that match names in the silkscreen layer of the Gerbers or on a markup sheet.

Use the Gerber file viewer or layout tools to record the X & Y positions of the Test Points, the board corners, and any mounting or tooling holes into a spreadsheet. If the origin and orientation of the Gerbers cannot be changed using the Gerber file viewer, the recorded coordinates will need to be transformed to reflect the final origin and orientation of the board.

After the positions have been recorded, print out the spreadsheet and check each recorded coordinate against the coordinates in the Gerber file viewer. **This is extremely important. The hole positions in the spreadsheet must be error free as errors in the Drill List will likely result in scrapping the Probe Plate and starting again.** If the spreadsheet of coordinates is error free, the coordinates of the Test Points, the board corners, and any mounting and tooling holes can be moved into a Drill List.

Guide Pins

For the mounting and tooling holes, use the Pin Gauges to measure the actual hole diameters and note the diameter of the hole in the pin column. Check the Gerber files for the expected diameters of those holes and ensure the actual measurements are within the specified tolerance. If there are discrepancies resolve them with the board supplier and select a diameter that you expect for future holes.

Pick the two holes that are in diagonally opposite corners for the Primary Guide Pins which will determine the board position. If the available holes are close together relative to the board size, consider using the edges for all or part of the location (see the next section). Mark the two holes as “Primary Guide” in the “Notes” column.

For boards with probe points at least 0.030” diameter, pick a Primary Guide Pin diameter that is about 0.005” to 0.008” smaller in diameter than the hole. Pick a standard drill blank diameter. Note that drill blanks are available in fractional inch, number gauge, and metric diameters. Enter the Primary Guide Pin diameter in the “Dia” column for the two Primary Guide Pins.

Pick a size for the Secondary Guide Pins. These pins are not used for positioning but rather are used to prevent the board from being inserted in an incorrect orientation. Mark the holes as “Secondary Guide” in the “Notes” column. The Secondary Guide Pin diameters should be at least 0.020” smaller than the hole to prevent touching when inserted. Choose a standard fractional inch diameter dowel pin size if possible. Enter these diameters in the “Dia” column for the Secondary Guide Pins.

Automatiq Measurement Systems	552 Acton Road Columbus, OH 43214		**Revision History** A - Original Drawing; 03 Jan 2021; BJB
CPRJ-90300	Drill List		
Test Fixture; Automatiq Measurement Systems; Demo Board			
CPD-92021	A-1	Last Rev 03 Jan 2021	

Notes: See CPD-92023 for mounting position.
Standard Hole Sizes
0.125 Socket - 0.0945" (2.40mm)
0.100 Socket - 0.0689" (1.75mm)
0.075 Socket - 0.0551" (1.40mm)
0.050 Socket - 0.0394" (1.00mm)
0.039 Socket - 0.0315" (0.80mm)

X	Y	Dia	0.125 Socket	0.100 Socket	0.075 Socket	0.050 Socket	0.125 Crown	0.125 L Chisel	0.100 Crown	0.100 Round	0.100 S Chsel	0.100 L Chisel	0.075 Crown	0.075 S Chsel	0.075 L Chisel	0.050 Crown	0.050 S Chsel	0.050 L Chisel	Special	Pin	Notes
																					Corners
0.0000	0.0000																				
6.5000	0.0000																				
6.5000	4.5000																				
0.0000	4.5000																				
																					Guide Pins
0.2500	-0.0655	0.1250																			Edge Guide
6.2500	-0.0655	0.1250																			Edge Guide
6.5655	2.7500	0.1250																			Edge Guide
6.2500	4.5655	0.1250																			Edge Guide
0.2500	4.5655	0.1250																			Edge Guide
-0.0655	3.2500	0.1250																			Edge Guide
																				Test Points	**Notes/Wiring**
0.4250	2.3360	0.0689		x																J1.1	
0.4250	2.4460	0.0689		x					x											J1.2	
0.4250	2.5560	0.0689		x					x											J1.3	
0.4250	2.6660	0.0689		x																J1.4	
0.4250	2.7760	0.0689		x					x											J1.5	
0.3140	2.3910	0.0689		x																J1.6	
0.3140	2.5010	0.0689		x																J1.7	
0.3140	2.6110	0.0689		x																J1.8	
0.3140	2.7210	0.0689		x																J1.9	
0.7500	3.9250	0.0689																		J2.1	
0.7500	4.1750	0.0689																		J2.2	
0.5500	4.0500	0.0689																		J2.3	
1.2880	4.1700	0.0689							x											J8(-)	
1.7880	4.1700	0.0689							x											J8(+)	

Edge Positioning

The edges are used for positioning only if there are no suitable holes for Guide Pins. In most cases the positioning is best accomplished with two Edge Pins on each of the two longest edges and a single Edge Pin on each of the two shorter edges. Usually 0.125” dowel pins work best and are least expensive.

The board routing is accomplished as a separate operation and seldom is as accurate as hole positioning. In addition, boards may be scored or perforated and broken or cut apart after assembly. This can add to the positioning errors. If there are routed edges or partially routed edges, attempt to locate the Edge Pins in these areas. The next best choice is scored areas. Avoid using perforated areas if possible. Locate the two Edge Pins on the long edges as close to the ends as possible.

Measure the length and width with digital calipers and compare with the specified width and length. If the dimensions differ significantly, try to determine which will be the size of future circuit boards.

Locate the pins with about 0.003” of clearance between the edge of the pin and the actual board edge.

Boards that must be located from the edges are usually less accurately positioned than boards with Guide Pins. If the board has through hole pins that are (or can be) probed near the four corners, they can take advantage of the Crown head’s self centering ability. Set one Crown head Pogo Pin near each corner and about 0.020” to 0.030” high (see the section on Probe Planes for details). When the board is loaded, it will further locate itself from these Pogo Pins much more accurately than the Edge Pins are locating it.

Choose Pogo Pins

Pogo Pins are available in sizes that can be mounted on various minimum center to center distances. Use 0.100” pins if possible. They are quite rugged and relatively inexpensive.

Pogo Pins are also available for mounting on 0.075” and larger centers. They are only slightly less rugged and slightly more expensive. They should be used freely when needed.

The 0.050” center to center pins are quite fragile and significantly more expensive. Hitting them with the board while loading and unloading is likely to bend or break them. Use them only when no other alternative is available.

The following table gives the absolute minimum center to center spacing for the various combinations of pogo pin sizes. Pin head size and drilling accuracy may limit the usable center to center spacing.

Pogo Pin Center to Center Spacing			
Pogo Pin Size	0.050” Pin	0.075” Pin	0.100” Pin
0.050” Pin	0.048”	0.059”	0.072”
0.075” Pin	0.059”	0.068”	0.080”
0.100” Pin	0.072”	0.080”	0.087”

A number of probe point heads are available:

- **Small Chisel** heads should be used for flat test points or test points that have a hole in the center (vias). These heads may make a small mark on the test point. If there is a hole in the pad, make sure that the probe is larger than the hole.

Pogo Pin Size	Head Diameter
0.050”	0.020”
0.075”	0.025”
0.100”	0.036”

- **Large Chisel** heads should be used for test points that have a hole in the center (vias) where the hole is too large for a Small Chisel.

Pogo Pin Size	Head Diameter
0.050”	0.035”
0.075”	0.046”
0.100”	0.062”

- **Crown** heads should be used to make contact with through-hole connector pins or through hole component leads. They are self centering.
- **Spear** heads should be used to make contact with SMD pads. They dig in and prevent slipping on sloped surfaces.
- **Round** heads should be used for test points that are gold plated and should not be marked. They are sometimes used as pins for female connector probing.

Pogo Pin Size	Head Diameter
0.075”	0.025”
0.100”	0.036”

- **Large Waffle** heads should be used for test points that are too irregular for other pins to work well. These heads need to be mounted on at least 0.140 centers.

Pogo Pin Size	Head Diameter
0.100”	0.122”

Mark the spread sheet with the Pogo Pin size and head style. Enter the nominal socket mounting diameter in the “Dia” column.

Pogo Pin Size	Nominal Hole Size
0.050”	0.0394”
0.075”	0.0551”
0.100”	0.0689”

See the Fabrication Chapter for the exact drill to be used to drill these holes.

Probe Planes

The Versi-Traq Test Fixture and the standard Push Down Pins (1.050” long) are designed to probe Test Points on the bottom surface of a 0.062” thick board located on a probe plane 0.188" above the top of the Probe Plate. Occasionally through-hole pins or connectors are not at this ideal test point height.

Pogo Pins can accommodate test points that are up to 0.062” below the ideal test point height with no additional adjustments, which means that Pogo Pins can accommodate test points at heights in the ideal range of 0.125" to 0.200" above the top of the Probe Plate. Note that circuit boards thicker or thinner than 0.062" will alter the height of the probe plane.

Pogo Pin Sockets in the Test Fixture can be mounted to protrude up to 0.250" above the top of the Probe Plate in order to accommodate probe planes higher than the ideal test point range up to 0.450" above the top of the Probe Plate. Use a spacer with a clearance hole for the Pogo Pin Socket to set the height of the Socket above the top of the Probe Plate. Shorter Push Down Pins can also be used to raise the height of the probe plane of the board.

Pogo Pin Sockets in the Test Fixture can be mounted in milled out pockets set down up to 0.065" below the top of the Probe Plate in order to accommodate probe planes below the ideal test point range down to 0.060" above the top of the Probe Plate.

The Test Fixture can accommodate probe planes even further above or below this range by using Auxiliary Probe Plates made of smaller pieces of FR4. Pogo Pin Sockets can be mounted on the Auxiliary Probe Plates which are then mounted above or below the Probe Plate using milled pockets and stand-offs to achieve the necessary height.

These Auxiliary Probe Plates are mounted onto the Probe Plate using either Epoxy cement or screws. If an Auxiliary Probe Plate is mounted with Epoxy cement, use the existing holes in the Probe Plate as a drill guide to drill holes in the Auxiliary Probe Plate on a drill press. Use steel drill bits as carbide PC Board drills will break with hand drilling. If an Auxiliary Probe Plate is mounted with screws, the mounting holes need to be as precisely located and drilled as the Test Points.

Some circuit boards require probing Test Points located on multiple probe planes. Mark the height changes required for each point in the "Notes" column.

A side view of a design study will help clarify the various options. Use DWG-00279 (in the Versi-Traq Documentation Package) as a starting place.

Drawings

Design Study

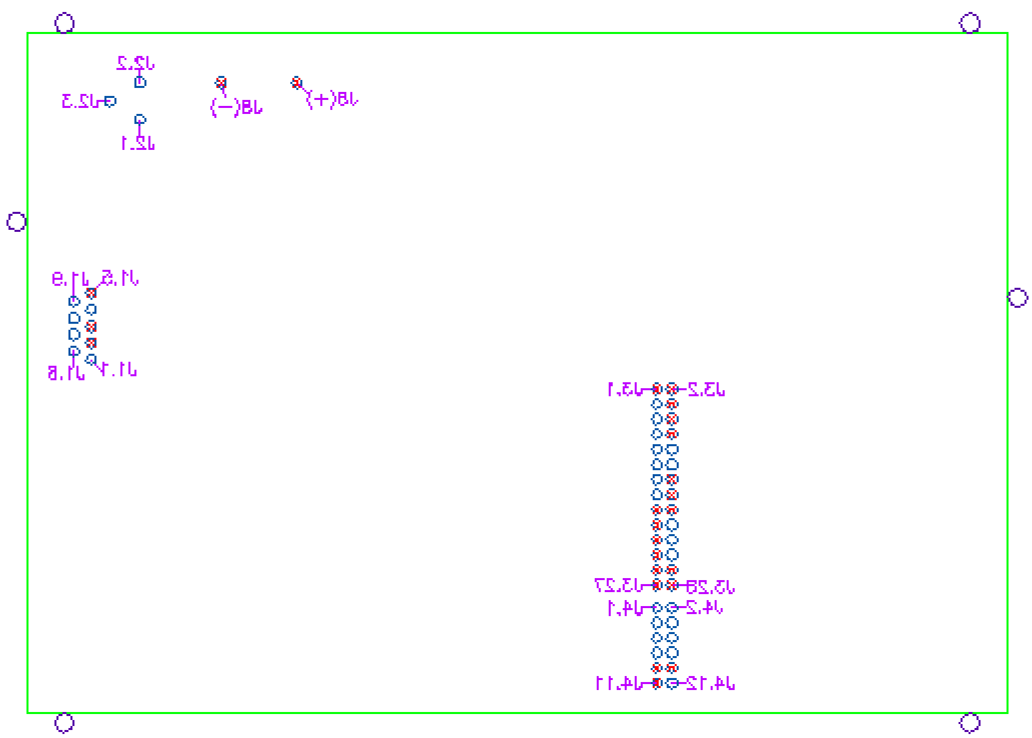
While not absolutely necessary, a Design Study of the circuit board with the mounting holes and Test Points is very useful for designing the Probe Plate and the Top Cover. It also provides an additional check of the hole positions. Finally, it provides the identification label for the bottom of the Probe Plate.

If your Gerber file viewer supports exporting DXF or DWG files, export the Top Silkscreen, the Top Circuit, the Bottom Circuit, the Bottom Silkscreen, and the Outline layers as necessary. Import them into the Design Study and register them with the origin of the board. If your Gerber file viewer does not support exporting the layers into the Design Study, the circuit board details can be drawn into the Design Study.

Draw the mounting holes on one layer of the drawing, using the coordinates from the Drill List. Similarly, add the Test Points from the Drill List on another layer. We have developed scripting tools to add the mounting holes and Test Points from the Drill List into the Design Study.

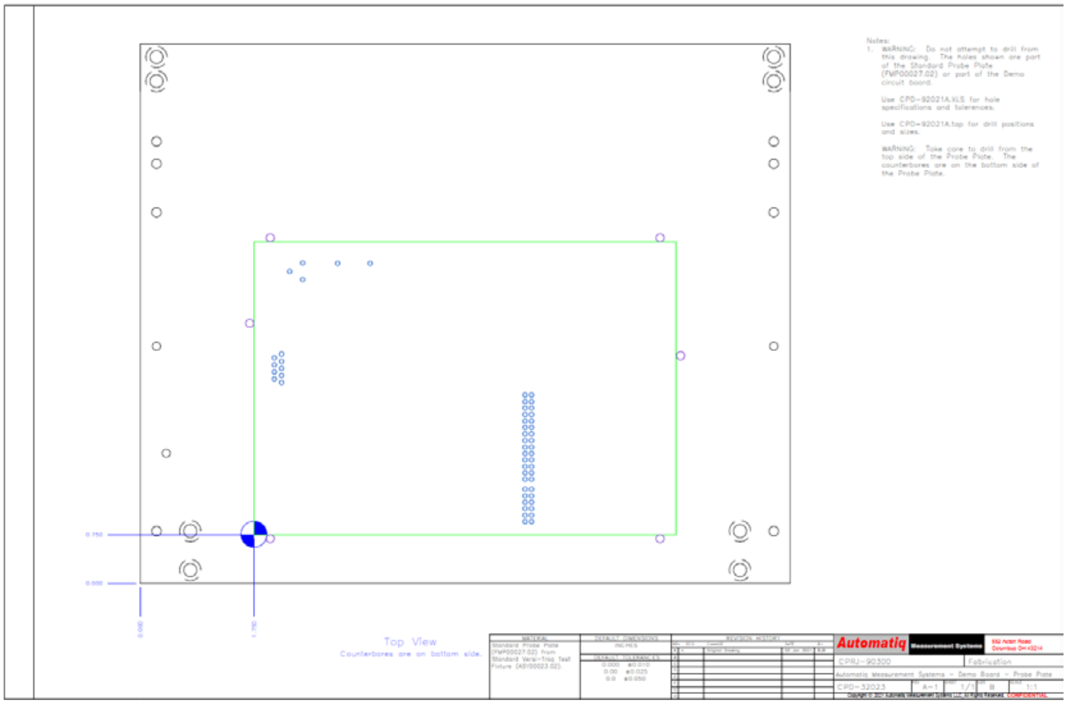
If the Design Study has Gerber layers, ensure that the Test Points locations from the Drill List match the Test Points on the board itself. The Drill List will need to be redone if there is an error.

Add the Test Point names on a new layer. Orient the names to be viewed from the bottom of the board as it is loaded in the Test Fixture. It is usually easiest to accomplish this by reflecting the board image, adding the names, and then reflecting the image back.



Location on Probe Plate

Using the Design Guide as a guide, locate the board on the Probe Plate drawing and mark the origin of the drill table for the board.



Probe Plate Machining

Add any other machining that may be needed on the Probe Plate drawing. In particular, add any cutouts or pockets that may be necessary to clear bottom components that protrude more than 0.170” below the bottom of the board. Be sure to mark the machining with the required depth. Remember to include any additional machining required for additional probe planes.

Top Cover and Push Down Pins

Using the Design Guide as a reference, locate the board on the Top Cover drawing. The easiest way to do this is to copy the board from the Probe Plate drawing using a base point at the center of the bottom edge of the Probe Plate. Paste it into the Top Cover drawing with the base point located at the center of the bottom edge of the Top Cover. **Note that the Probe Plate and the Top Cover are not the same width. Locating from the bottom left corner will result in errors.**

Push Down Pins are driven into 0.125” diameter holes. Start out by locating positions for Push Down Pins near the corners. Remember to position Push Down Pin locations with some space on the board in front of the placement. Also be aware that the tip of the Push Down Pin could hit tall components on the board as the Top Cover closes. If necessary, the side view design study can be used to trace the arc of the Push Down Pin tip.

Design

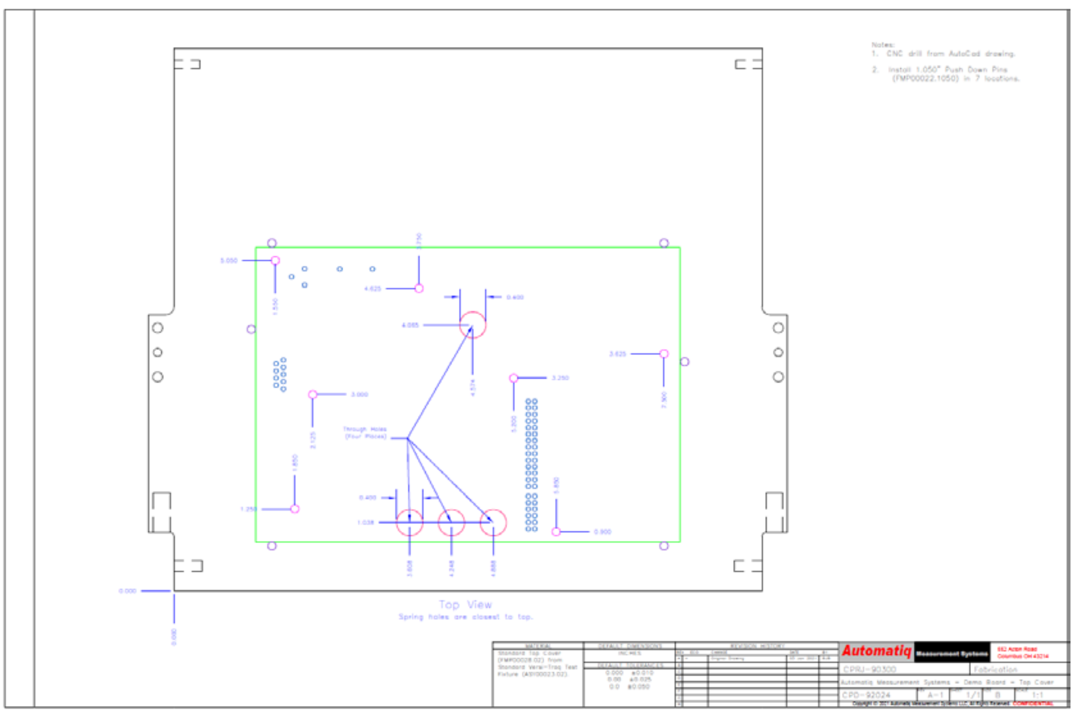
If the Design Study has Gerber layers, display the Top Circuit and Silkscreen layers for use with positioning Push Down Pin locations. If the Design Study does not have the Gerber layers, we find it easiest to use digital calipers to accurately locate the components on the Sample Board and to use the CAD drafting package to add the components on the Top Cover drawing.

Remember to allow some space in front of the final location of the Push Down Pin for it to land as the Top Cover rotates down. Also be aware that the tip of the pin could hit tall components as the pin rotates into place. If necessary, the side view Design Study can be used to trace the arc of the pin tip.

Place additional Push Down Pins near groups of Test Points at the rate of at least one pin for every ten Test Points. It is important to prevent the circuit board from flexing as the Pogo Pins push up on the bottom and the Push Down Pins push down on the top. If flexing is observed after assembly, additional Push Down Pins can be installed. Be particularly careful with thin (<0.062") circuit boards and with boards that have large BGA packages. In some cases we have used Push Down Blocks for thin boards with no components on the top side (as mounted).

Finally the Push Down Pins must be located so they will not hit any Pogo Pins if the fixture is closed without a circuit board installed. **If they hit a Pogo Pin when the Top Cover is closed without a board, the Pogo Pins will be bent and destroyed.**

Sometimes Push Down Pins will need to be filed down to clear components. They can be filed to half their original thickness without concern.

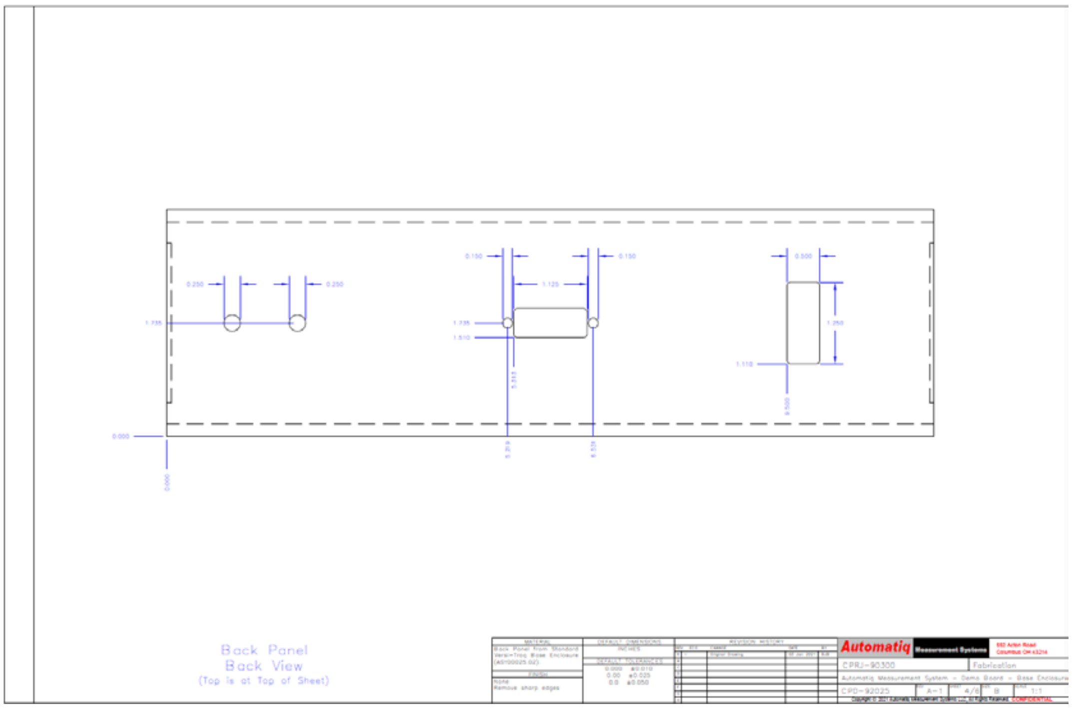


Top Cover Machining

Add clearance cutouts or pockets for tall components to the Top Cover drawing. Add cutouts for access points if necessary. Ensure that the machining does not interfere with the Push Down Pin locations.

Enclosure Machining

Add cutouts and holes as necessary to the Base Enclosure drawings The Base Enclosure drawing provides views of all six sides of the enclosure.



Other Issues

Safety Skirts

Boards that have more than about 48V applied while testing should have Safety Skirts installed to prevent the operator from contacting the high voltage. The Safety Skirts are fabricated from 0.250” thick, 1.00” tall clear polycarbonate and are screwed to the bottom of the Top Cover and the top of the Probe Plate. The skirts should completely surround the circuit board. Take care that the back Safety Skirt clears the board while it is rotating down if it is fastened to the Top Cover.

Make sure that there are no live top components that have clearance cutout holes in the Top Cover. Make sure that any access cutouts are too small for fingers to go through and insulated tools are used for access.

In most cases, an Interlock Switch should be provided to remove the high voltage if the Top Cover is not closed.

Interlock Switch

An Interlock Switch is available from Automatiq. It is mounted on a modified Latch Tower and closes only after the Top Cover is completely down and the Latch is locked.

Note that the modified Latch Tower is slightly deeper than the standard one. This affects the available space for mounting the circuit board under test.

We recommend that a push button switch be provided to start the test and if necessary, another push button be provided to halt or reset the test as well as a light to indicate that a test is in progress. The Interlock Switch should be used to prevent starting the test, not used to start the test itself. Using the Interlock Switch to start the test encourages the operator to open and shut the cover during a test. This often results in opening or closing the fixture with power on the pins. This can result in erratic operation or damage to the fixture or board.

The switch used for the Interlock Switch is only rated for 100mA. Also, the insulation on the switch is not suitable for high voltage. **Do not use the Interlock Switch to directly switch the high voltage.**

Cables

The test may require that cables be plugged into the circuit board under test. Most connectors have rated service lives of only a few hundred insertions. In addition, the cable itself will break after enough insertion cycles.

We recommend that cables to be plugged into the circuit board be designed as jumper cables between the circuit board connectors and connectors on the top of the Base Enclosure. If the cable fails, just replace the jumper. You will find that the cable will probably be the most failure prone item in the test system. Make extra cables and install them at the first sign of trouble. Some users replace the cables after a specific number of tests even if it has not failed.

Chapter 5 Fabrication & Assembly

This chapter describes the issues and procedures required to fabricate, assemble, and wire the customized Versi-Traq Test Fixture.

Required Tools & Supplies

A number of tools and supplies are necessary or helpful for the fabrication. These are in addition to those that are usually available in a prototyping machine shop and electronics lab.

Supplies and Consumables

There are several supplies and consumables that are required or helpful:

- **Drills:** Holes for Pogo Pins Sockets and Guide Pins should be drilled with solid carbide PC drills. Most mill supply houses carry solid carbide drills with 0.125” shanks. See the information in this chapter for required diameters. Do not attempt to use standard drills. Do not attempt to use the carbide PC drills by hand in a drill press as they will break quite easily.
- **Drill Blanks:** Guide Pins are most easily made from precision ground drill blanks. Most mill supply houses carry a line of drill blanks. Note that fractional inch, number gauge, and metric sizes are available.
- **Dowel Pins:** Precision ground dowel pins are available in fractional inch sizes and specific lengths. Where applicable, they are much less expensive than drill blanks and they do not require cutting to length. They are available from mill supply and fastener houses.
- **Pogo Pins:** Pogo Pins and Sockets are available from Automatiq as well as Pogo Pin manufacturing companies.
- **Push Down Pins:** Push Down Pins to push the circuit board down onto the Pogo Pins are available from Automatiq.
- **Foam Spacers:** Foam spacers to stabilize the circuit board are available from Automatiq.
- **Shrink Tubing:** An assortment of shrink tubing sizes will be necessary for wiring. Some electronic suppliers can provide small sizes precut in ½” lengths. These are particularly useful.

Tools

There are a number of tools that are necessary or helpful:

- **Drill/Mill:** The holes for the Pogo Pins and Guide Pins must be drilled very accurately. The best option is a high speed CNC Drill or Router. The minimum requirement is a mill with digital readouts. The faster that the drill turns, the more accurate the position and diameter of the drilled hole. Do not attempt to use a drill press or mill without digital readouts.

- **Cutoff Grinder:** A miniature cutoff grinder will be necessary to cut the drill blanks made of hardened steel to length. A Dremel tool with a cutoff tool and some jigs will work.
- **Insertion Tools:** We use custom designed tools that mount in an arbor press in order to press the Pogo Pin Sockets into the Probe Plate. Automatiq or the Pogo Pin manufacturer can provide insertion tools to drive the pins in.
- **Heat Gun:** You will need a small heat gun. We recommend the Weller 6966C as being particularly well suited to the smaller size shrink tubing.

Fabrication

In addition to normal machine shop practices, there are some additional issues that should be considered.

Tool Pins

The Probe Plate and Top Cover are provided with tool holes for location from 0.125” tooling pins. It is best to make a base plate with these tooling pins to ensure that the Probe Plate and the Top Cover are located accurately when they are machined. The edges of the Top Cover and the Probe Plate are not located as accurately as the tooling pin holes.

Hole Diameters

In addition to the specified drill diameter, the drilled hole diameter may depend on the material, drill speed, drill style and quality, and the drilling machine. For high accuracy drilling (for the Pogo Pin Sockets) it is a good idea to drill a sample hole in scrap material with the final equipment, drill, speed, etc. and check the actual hole diameter with a gauge pin or the socket.

When starting a drill hole, the drill bit may wander a bit before starting the hole. Because of the drill geometry, this can result in a hole that starts slightly off position and angles away from the position as it goes through the material. Material like FR4 which is not uniform exacerbates this problem. Solid carbide PC drills with 0.125” shank provide additional stiffness to minimize this problem. Spinning the drill faster also helps. High speed CNC drills run at 25,000 rpm or faster. Use solid carbide PC drills turning as fast as possible for the best accuracy.

CNC Drilling

If a CNC Drill or Router is available, use their associated software tools to generate drill files from the coordinates in the Drill List. Use the Probe Plate drawing to locate the coordinates for the origin of the drill table.

Hand Drilling

If drilling on a mill with digital readouts, set the Probe Plate or Top Cover readout origin using the tool hole positioning fixture. Move to the drill table origin, switch to relative readout, and zero the readout. Manually set the position of each hole from the drill table and drill the hole.

Pogo Pin Holes

The following table shows the solid carbide PC drills with 0.125” shank that we use at Automatiq on our equipment. Your drills and equipment may differ slightly.

Pogo Pin Size	Specified Hole Size	Recommended Drill
0.050”	0.038” – 0.039”	1.00mm (0.0394”)
0.075”	0.053” – 0.055”	1.40mm (0.0551”)
0.100”	0.067” – 0.069”	1.75mm (0.0689”)

Guide Pin Holes

Traditionally, Guide Pin holes were drilled slightly smaller than the pin diameter and the Guide Pins were pressed into the undersized hole. We have found that this results in poor positioning because of slight bending and angled insertion. We recommend drilling the hole with a solid carbide PC drill the same size as the Guide Pin. This hole still allows the Guide Pin to be pressed into place.

Push Down Pin Holes

We drill the Push Down Pin holes with 0.125” diameter holes with a solid carbide PC drill. When drilling the polycarbonate, heat buildup can melt the plastic. We find that a lower rotation speed along with a relatively heavy feed gives the best results. On the CNC Router, we use a pecking drill pattern to clear the chips and let the bit cool.

After drilling, make sure that any burr is removed with a counter sink tool so that the Push Down Pin fully seats in the Top Cover.

Insertion

The Guide Pins, Pogo Pins, and Push Down Pins must be inserted after drilling and machining the Probe Plate and Top Cover.

Guide Pins

We use 1.00” long Guide Pins made from either precision ground dowel pins or drill blanks depending on the diameter pin required. Drill blanks do not come in 1.00" lengths, so they will need to be cut to length, using an abrasive cutoff wheel as they are hardened steel. We place the drill blanks in a small guide that sets the length to 1.00" so we can cut them to length with a small cutoff wheel in a Dremel tool. We then use a hand drill to hold the cut drill blanks in order to grind flat and bevel the ends with a fine grinding wheel.

The 1.00" long Guide Pins are set into the appropriate Guide Pin holes and pressed into place so that the end of the Guide Pin is set level with the bottom surface of the Probe Plate. If the Guide Pin does not have a tight fit and can be removed by hand, the Guide Pin will need to be glued into place. Before gluing the Guide Pin into place, apply a primer to the Guide Pin. Then apply super glue to the Guide Pin and quickly press it firmly in place.

After the Guide Pins are installed, make sure the sample board fits smoothly over the Guide Pins. Note that the boards must be kept relatively level or it will bind.

Note that if the “Loaded Board Height” is modified due to nonstandard probe planes, the length of the Guide Pins may need to be adjusted.

Standoffs

For inserting Pogo Pin Sockets and subsequent steps, we use four standoffs with 10-24 threaded studs that screw into the mounting holes on the bottom of the Probe Plate. They provide clearance for the Pogo Pin Sockets when they are inserted into the Probe Plate.

While you can use spacers to hold up the Probe Plate, if it slips off, the sockets will be bent and ruined. The extra security of using standoffs makes the time required to fabricate them a good tradeoff. This is particularly true when you will be testing the unmounted fixture in later steps.

Pogo Pin Sockets

With the Probe Plate located on standoffs, insert the Pogo Pin Sockets from the top. Use an insertion tool and tap them in with a small hammer. If you install lots of Pogo Pin Sockets, you may want to fabricate an insertion tool that mounts in a small arbor press with a table and press them in.

Pogo Pin Sockets are normally installed flush with the top of the Probe Plate. In some cases, they need to stand proud of the Probe Plate (see Probe Planes section). Use a spacer with a clearance hole for the Pogo Pin Socket to set the height of the Socket above the top of the Probe Plate. Do not install the Pogo Pins at this time.

Push Down Pins

Push Down Pins are installed into the bottom of the Top Cover. Make sure that the holes have a slight chamfer on the bottom side. Use a small hammer to tap the Push Down Pins into the Top Cover. Make sure that the pin is driven in until the shoulder is solid against the bottom of the Top Cover and the tips define a plane.

Assembly

Pogo Pins

With the Probe Plate still on standoffs or spacers, install the Pogo Pins. Test the sample board for fit. You may be able to see probe marks on a new sample board to verify probe positions.

Push Down Pins

Assemble the Versi-Traq Test Fixture except for the Lid Lifters. Use drawing DWG-00281 for instructions.

Make sure that the Push Down Pins do not hit the Pogo Pins when the fixture is closed without a circuit board installed.

Load the sample board and see that the board loads and unloads smoothly. Check that the Push Down Pins do not hit any components on the sample board. If a Push Down Pin touches any components, the Push Down Pin will need to be moved or modified. Up to half of the tip can be filed away.

View the loaded circuit board from the edge and note any excessive deflection of the circuit board. If there is excessive deflection, the Push Down Pin locations will need to be reworked.

Foam Spacers

Some Test Fixtures have Pogo Pins spread out such that the circuit board is evenly supported as it is being loaded. In other fixtures, the board may tend to tilt and bind up. If so, install Foam Spacers under the corner Push Down Pin locations to stabilize the board as it is loaded and unloaded. Try placing the spacers without exposing the adhesive until they work properly and then stick them down. The Foam Spacers can be cut in half or otherwise if necessary to get a good fit.

Rework

If Push Down Pins need to be moved or added, remove the Top Cover and remove the Push Down Pins by tapping them out from the top with a small pin punch.

Add or move the holes and reassemble the Test Fixture. Ensure that the new or moved Push Down Pins do not hit any Pogo Pins when the Test Fixture is closed without a circuit board installed and retest the loaded circuit board for excessive deflection.

Final Assembly

With the Probe Plate still on standoffs or spacers, install the Lid Lifters. Test the operation of the fixture with the sample board.

Test Point Identification

Print a 1:1 copy of the circuit board Design Study from the back side on label stock. Use a punch or X-Acto knife to cut out the Test Points. Remove the release paper and mount it on the bottom of the Probe Plate to identify each of the Test Points.

Mount on Base Enclosure

Assemble the Base Enclosure except for the Bottom Cover.

Place the fixture upside down on a bench and remove the standoffs. Place the Base Enclosure upside down on the fixture and install the four 10-24 mounting screws and lockwashers.

Extra Pogo Pins

If there are extra Pogo Pins that are not being used, it is usually wise to remove the Pogo Pin. This will make the Top Cover easier to close. Some Pogo Pins may provide stability for the board as it is being loaded and should not be removed even when unused.

Assembly Parts List

Provide an Assembly Parts List that lists all parts used in the Test Fixture.

Chapter 6 Wiring

Good standard wiring practice covers most aspects of wiring a Test Fixture.

However, Test Fixtures experience tens of thousands of test and loading cycles and rough handling when in storage. This is a challenge to wiring technique.

Strain Relief

Our experience indicates that wire flex at connection points is the major failure mechanism for a well engineered test system. Without strain relief, any flexing of the wire concentrates the strain where the wire emerges from a solder joint. It will break after relatively few flex cycles.

There is a simple solution. Cover every solder joint with shrink tubing. Make sure that the shrink tubing extends from the solder receptacle, over the stripped portion of the wire, and over at least ¼" of the insulated wire. This will provide insulation, reinforcement of the solder joint, and strain relief of the wire.

Many of the circuits can be wired with #26 or #28 stranded wire. As long as they are strain relieved with shrink tubing, they will be very reliable. Use larger wire only if the current requires heaver wires. Heavy wires can put excessive strain on connection points and bend or break the solder terminals.

Pogo Pins

The Pogo Pin Sockets have a solder cup at the bottom end. Tin the solder cup. Strip and tin the wire. Slip a ½" length of the appropriate size shrink tubing over the wire and solder the wire to the socket. Slip the shrink tubing over the solder joint and wire and then shrink. This provides insulation around the solder joint and more importantly, strain relief for the wire.

Prototyping Boards

Small pieces of perforated prototyping board provide quick and reliable locations for simple circuits, load resistors, etc. for Test Fixtures. However, connecting them to wires is often a problem.

The easy way is to push a stripped and tinned wire through a hole and solder it on the back side. Unfortunately, there is no way to strain relief the wire and it will break off after a few flexes.

There are several possible solutions. A 0.100" x 0.100" header can be located on the board and the circuits connected to its pins. A mating IDC cable can be constructed using color coded ribbon wire. The wire can be stripped apart and wired wherever needed.

Otherwise, wires can be soldered parallel to the pins with shrink tubing slipped over the wire and the pin for strain relief.

Two Wires

If two wires are required on a single Pogo Pin, strip each of the wires 1/8” to 3/16”. Twist the wires together and tin them. Slip a ½” length of shrink tubing over the pair of wires and solder to the Pogo Pin. Position the shrink tubing over the Pogo Pin and wire and shrink.

Splicing Wires

If wires need to be spliced, strip the wires for 1/8” to 3/16” and tin them. Slip a ½” length of shrink tubing onto one of the wires. Overlap the tinned wires (parallel) and solder. Move the shrink tubing over the splice and shrink. Do not attempt to twist the wires or hook them together.

Schematic

If necessary, provide a Schematic of the Test Fixture wiring. Note any special conductor sizes, cable lengths, and other wiring issues.