Micro Test System – µTS

Modular Universal Under-Microscope Load Frames

User Manual

Hardware Version 4.121
Software Version 2.4.3
Manual Version 1.12

Table of Contents

1 Introduction

1.1 Overview

The Psylotech µTS system [system] is a flexible meso-scale test system which is designed to be used in conjunction with a microscope and digital image correlation (DIC) system to measure stress/strain, stress relaxation and creep experiments on a wide range of materials. The system consists of three main components: the mechanical frame, control computer and test hub.

1.2 Mechanical Frame

The motors, load sensor, displacement sensor and grips all make up the mechanical frame. The frame is designed to apply the testing regime that you specify. See Figure 1.1 for more information on each part of the system.

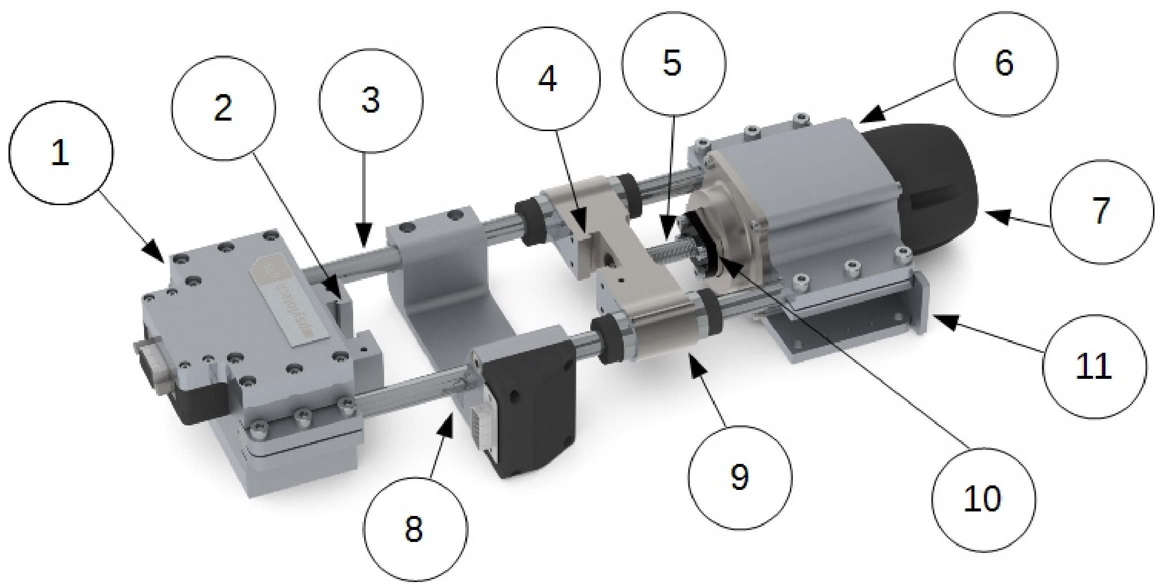


Figure 1.1 µTS Test Frame, 1. Fixed Crosshead and Load Cell, 2. Fixed Grip Mount, 3. Support Shaft, 4. Moving Grip Mount 5. Ball Screw, 6. Actuator Housing, 7. Rotary Encoder, 8. Local Displacement Sensor 9. Moving Crosshead 10. Ball Nut, 11. Cable Egress

1.3 Computer

The system is controlled with a Windows 7 x64 based Intel PC. The computer is controlling the test frame in real time. Therefore, minimize the number of other programs running while Psylotest is running.

The control computer **must be separate** from the DIC image acquisition computer.

1.4 Test Hub

The motor control, sensor signal conditioning, and power electronics are in the test hub. Do not open the test hub as it contains high voltages and sensitive electronics.

Figure 1.2 has a depiction of all Psylotech provided components.

Figure 1.2 Test Hub, Control PC, Control PC Monitor, BXFM Microscope and µTS

1.5 Software

The system is controlled with a National Instrument's LabVIEW Program and PCI Express data acquisition card [DAQ card]. All the software and hardware is installed in the computer.

2 Safety

Please consider the following safety precautions before installing or using the system.

2.1 Electrical Currents

The test hub is a power conditioning and transforming device. It takes the AC input from the wall and converts it into various AC and DC voltages (at or below 120VAC RMS, or 220VAC for regions outside of the USA). Do not open the test hub unless instructed to do so by a Psylotech representative. If bare or cut wires are noticed, turn off and unplug the system immediately and notify a Psylotech representative.

The motor power cables carry the bus voltage that drives the actuator. If this cable becomes disconnected, it could be carrying a live current if the system is on and the actuator is enabled. While the connectors that pass the electricity to the motor are designed to be tamper-proof, it is possible to access these signals. Avoid sticking metal parts into female sides of connectors.

2.2 Specimen Particulates

When testing high modulus specimens to failure, quite often there is a high impact load on the system and specimen at the failure point. This can cause small and large particles to get thrown in directions all around the system. Take the proper precautions and always wear protective eye wear when using the system.

Some specimens may also be pulverized and crushed into a find powder; in this case, it is important to know if the specimen is toxic when inhaled. Avoid contact to specimen particulates in the air and take all precautions assuming that any specimen may become airborne and enter the respiratory system.

2.3 Pinch Points

All three frames are capable of fast speeds (up to 100mm/s), accelerations (10m/s^2), and high loads (up to 10kN). During any usage of the system it is important to keep hands and sensitive objects away from the load frame. The specific pinch points are anywhere the crosshead can travel, especially near the tensile limit of the stroke. Between grips is another spot to watch out for.

The rotating ball nut (μTS, μTS10) or screw (nTS) in the system can cause a safety hazard if bodily objects get caught while the frame is moving. Avoid leaning over the system with items dangling from your person, including but not limited to: neck ties, ID lanyards, and long hair.

2.4 Temperature

The actuator that turns rotary motion into linear motion is powered by an AC servo-motor. When at high loads respective to the system limit (i.e. 10kN load on the 10kN µTS) for extended periods of time, the motor housing and nearby parts may become very hot to the touch. They may reach 100 degrees Celsius. Avoid touching these areas during usage of the system, especially if using the actuator at high loads.

3 Installation

3.1 Site Preparation

3.1.1 Space

Each system requires a footprint that depends on certain configured options. See Section 6 for guidelines on the default system configurations.

The Test Hub must be within 3 meters of the frame and the control computer must be within 2 meters of the test hub. These distances are limited by the cable length.

3.1.2 Power

Three outlets are needed: the computer, monitor and test hub. The system is setup to operate at the local power level which is 50-60Hz 120VAC with NEMA15-5P or 50-60Hz 220VAC with Schucko plugs.

The power at the location of the test hub and control PC needs to be free of noise and transients. The highly sensitive nature of the electronics requires that no other heavy machinery or noise generating electronics are on the same circuit or physically near the test hub, control PC, or load frame.

If imaging is to be performed, an additional 2 outlets are required for the imaging computer and imaging computer monitor.

3.1.3 Environment

The system is designed to operate in a laboratory at 15° - 35° C. The electronics, load cell and displacement sensors are sensitive to changes in temperature. The test hub and sensors will need to warm up for at least 30 minutes before use.

3.1.4 Tools

Various metric Allen hex keys are supplied with the system at delivery.

Other tools should be procured for optimal usage of the system. Below are the extra tools ranging from most to least necessary:

Caliper and/or micrometer with a resolution of .05mm or better

Various shims for specimen mounting; listed in the grip section of your specific system

Surge protector for Test Hub and Control Computer electronics

A torque wrench capable of 3-10N-m torque ranges and various metric hex bits

Kim-wipes for optics and specimen cleaning

Sharpie markers for specimen cataloging and potential speckle pattern

Manual y-stage for positioning under microscope – talk to Psylotech for compatible options

3.1.5 Microscope

The system is designed to work with a boom mounted microscope on a vibration isolation table. Psylotech is a distributor for Olympus microscopes; contact us for help specifying the optimal setup for imaging.

3.2 Assembling the System

Unpacking, assembling, and commissioning the system should be left to trained installation personnel.

3.2.1 Test Hub

The Test Hub (Fig 3.1) is configured for the specific system.

Signal conditioning boards for load cells, extensometers, displacement sensors and temperature sensors that are included in your system plug into the 8

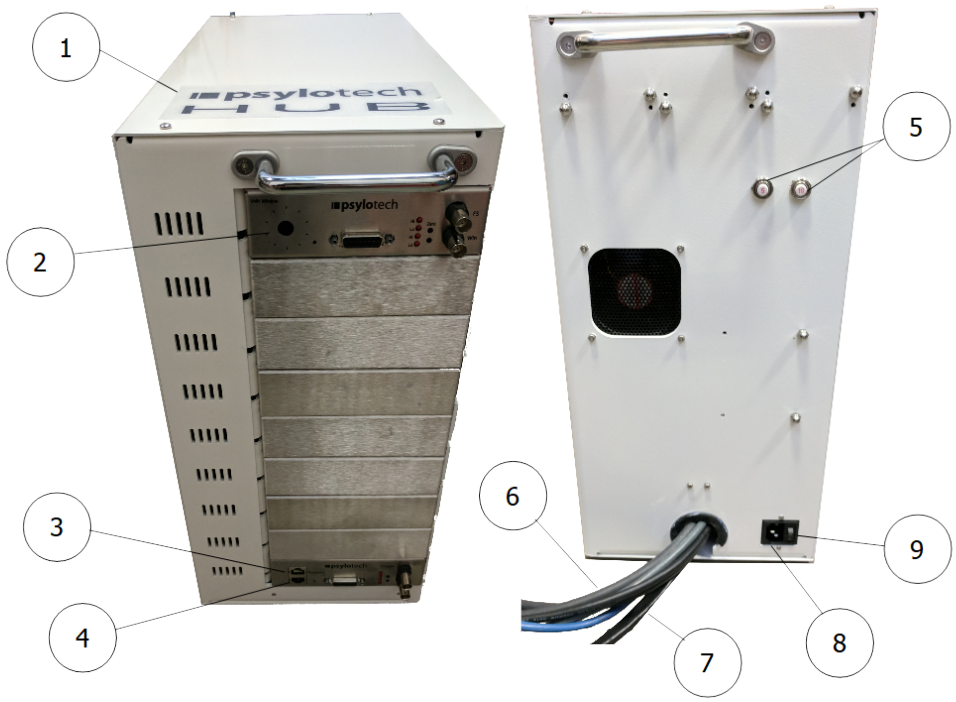


Figure 3.1 1. Test Hub, 2. Signal Conditioning Card, 3. Test frame stop switch, 4. Emergency stop/jog button pendant, 5. Circuit Breakers, 6. Motor Power and Sensor Cables, 7. Data Acquisition Cable, 8. Power Cable, 9. Power On/Off switch.

slots on the front of the Test Hub. These boards have been calibrated for the specific sensors that have been shipped with your system. It is important that the signal conditioning board is paired with its sensor.

Motor drives for controlling the servo-motors are in the Test Hub. Power conditioning is also performed in the Test Hub.

On the front of each signal conditioning card you will notice, from left to right (Figure 3.2):

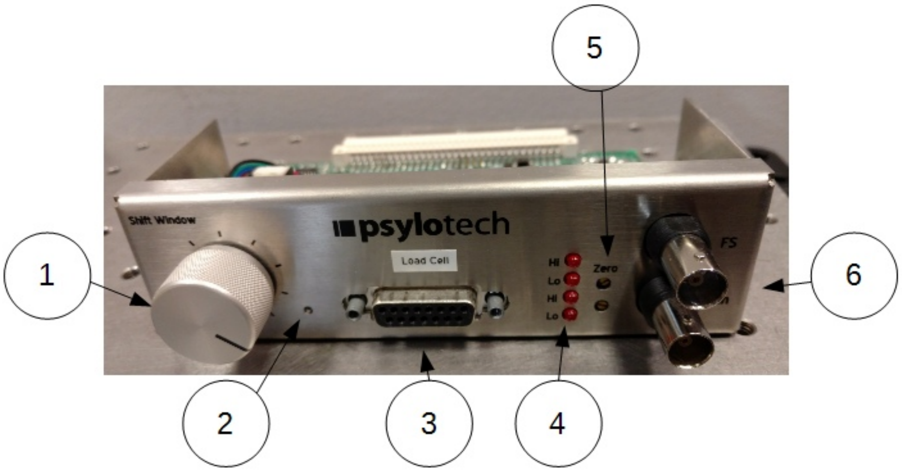


Figure 3.2 Sensor Front Panel 1. Window Shift Knob, 2. Unused Hole, 3. Sensor IO D-Sub, 4. Sensor Zeroing LEDs, 5. Sensor Zeroing Potentiometers, 6. +/- 10 V Sensor Output BNCs

1. A knob. This knob controls the window position if the sensor is a Psylotech Windowing sensor. This knob will change which range is being zoomed into, and will stay there unless autoshifting is turned on.

2. Small hole. This hole does not have a function in test system applications.

3. Fifteen pin D-subminiature connector. This is where the sensor gets connected.

4. Vertical red lights. These lights show where the two sensor ranges (full scale and window) are in relation to zero volts (center of range). The upper two lights refer to the full scale while the lower two refer to the window range. If the top light of either pair is on, then that sensor is above zero. If the bottom of either pair is on, then that sensor is below zero. If the sensor is right around zero volts, the two lights will flicker between on and off.

5. On some systems only; two vertical adjustment screws. These are for calibration and **only to be used by trained re-calibration professionals. Please leave them as they are**.

6. Two vertical BNC connectors. The top BNC outputs the full scale sensor reading in volts, from -10 to +10 volts. The bottom BNC outputs the window in a similar fashion.

Keep in mind that the window is 25-100x (depending on configuration) more sensitive than the full scale.

3.2.2 Mechanical Test Frame

See Section 6 for drawings of each system

Place the test frame under the microscope. For best results the microscope and test frame should be on a vibration isolation table.

The frame comes with an impact resistant case to protect it during shipment. When not in use for extended periods it is prudent to store it in this case.

3.2.3 Cables

3.2.3.1 Ambient environment rated systems (15° - 35° C, relative humidity < 50%, 1 atm):

The **power cable** is a 9-pin 2-row heavy duty d-subminiature connector that includes the servo motor power and a grounding cable.

The **encoder cable** is a 15-pin 3-row high density d-subminiature connector that includes the encoder feedback and motor thermal limit measurement.

Each **sensor cable** has a 15-pin 3-row high density d-subminiature that connects near the frame. The side connected to the test hub has a 15-pin 2-row d-subminiature connector. Psylotech premium sensor cables also contain the integral sensor temperature tracking device which connects to a separate card on the test hub. Additionally, Psylotech premium displacement sensors include an integral displacement limiting switch for fast hardware stop action. This RJ-45 ethernet style connectors plugs into the lowest slot (auxiliary input) of the Test Hub.

Strain gauge and other sensor devices may have different connectors on the sensor side, but the hub side termination is always a 15-pin 2-row d-subminiature.

3.2.3.2 Vacuum environment rated systems (0-55 degrees C, relative humidity < 50%, 1E-5 Torr):

The **power cable** is a 15-pin 2-row d-subminiature connector that connects through a feedthrough. It includes the servo motor power, encoder feedback, motor thermal limit measurement, and a grounding cable.

The **sensor cable** is a 15-pin 2-row d-subminiature that connects through a feedthrough. The side connected to the test hub has a 15-pin 2-row d-subminiature connector as well. Strain gauge load cells will connect directly through.

3.2.3.3 For all systems:

The **Emergency Stop and Jog Pendant cable** plugs into the lowest slot (auxiliary input) of the Test Hub. This component is optional and not supplied with all systems. Call Psylotech to inquire about availability for your system.

The **DAQ Cable** is the thick black cable that comes out the back of the Test Hub and goes to the DAQ card in the computer. It should be screwed in tightly.

An **Ethernet cable** comes from the rear of the Test Hub and goes to the Ethernet connector on the computer. This allows IP based communication from the controller to the servo drive(s).

Some systems are outfitted with a second Ethernet cable labeled "**EtherCAT**." This should be plugged into the EtherCAT labeled network card on the back of the control computer. This advanced feature allows high resolution digital control and feedback from the drive in sync with the 500Hz control rate of the controller.

Computer Cables such as the monitor, mouse, keyboard go into the displayport, USB, and USB connectors on the computer, respectively.

Power Cords for the Computer, Monitor and Test Hub plug into the rear of each component. Systems may be outfitted for 120VAC thru 240VAC depending on the region.

3.3 Powering up the System

When all of the cables are connected, turn on the test hub and control computer.

The system will need to boot-up and initialize before you can start moving the motors on the test frame, about one minute.

The signal conditioners and sensors should also be given at least 30 minutes to warm up if the system was started from a cold state.

4 Psylotest Control Software

4.1 LabVIEW Software Basics

The application software is written in LabVIEW and a cursory knowledge of LabVIEW will help you navigate the screens and adjust graphs to match your testing regime. See Chapter 12.1 for a LabVIEW usage background

Psylotest software is applicable to all test systems that Psylotech produces. The procedures for each one are the same, except for limits of load, stroke, and positioning resolution.

4.2 Psylotest Software

Start the program by clicking on the desktop or toolbar shortcut with the Psylotech icon:

The splash screen (Fig. 4.1) will now open. Loading the program will take a few moments

Figure 4.1: Splash screen

As Psylotest starts up it initializes the motor controls and feedback sensors. All cables must be in place and the Test Hub must be powered up.

Some portions of the Psylotest program are visible during all phases of use (Fig 4.2). These include important readouts and critical controls such as disabling the actuator in the case of an emergency.

Also shown at all times are the "Send all Windows to Range" button, the point interval time, and the "Clear All Displayed Data" buttons.

On a system with Psylotech Windowing Sensors the "Send all Windows to Range" button will send a one time command that centers all window sensors. This is done to ensure that the sensors are ready to output data and be used as a control feedback sensor.

Changing the displayed point time interval will allow for higher or lower sampling rates getting updated to the front panel. This option does not affect either the controller or the data being saved to disk. The minimum time is .05 seconds, or 20Hz. Up to 2000 points will be displayed no matter what time interval is chosen.

After a large step load or displacement change it can be hard to see small changes in a signal. The range of the plot will greatly overcome the resolution and area of interest in the size of the screen. If this happens it is useful to click the "Clear All Displayed Data" button to clear all data from the front panel and start fresh. Note that this does not affect the controller, the sensor zero values, or the saved data.

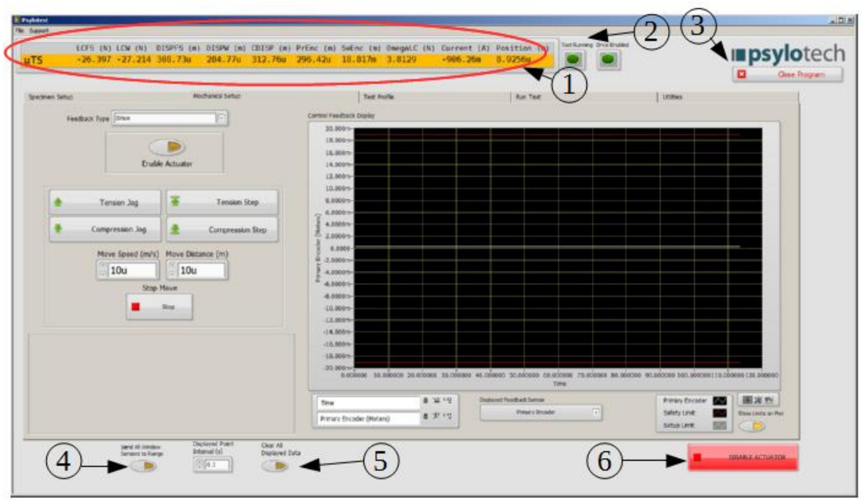


Figure 4.2 Initial Setup Screen: 1. Sensor Values, 2. Actuator Enabled and Test Running Indicators, 3. Close Program Button, 4. Send all Windows to Range Button, 5. UI Update Rate Timing Controls, 6. Disable Actuator Button

The first tab in the software layout is the specimen dimensions tab (Fig. 4.3). Here you will enter the specimen size (which will dictate dimensions for stress/strain plots and also be output in your data file) and also zero the sensors and set limits. It is a good idea to zero the load cell before loading the sample.

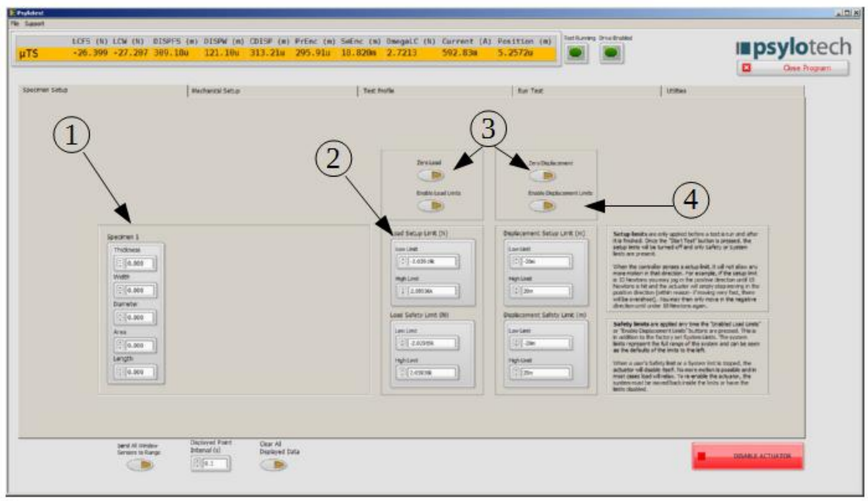


Figure 4.3 Specimen Setup Tab: 1. Specimen Dimensions, 2. Load and Displacement Limit Values, 3. Zero Sensor Value Buttons, 4. Enable User Limits Buttons

Setup limits are set to enable protection from overloading while mounting your specimen. These limits are only active if the "Enable Limits" button is selected AND the test is NOT running. The actuator will only allow movement in a direction until one of these limits is hit; it will stop itself when it hits the limit and not allow any more motion in that direction (CAUTION- if you command the actuator to move very fast the system will not stop itself in time to stay under the limit).

An example of the setup limits in use is to preload a specimen to a certain load; let's say 50N on a dogbone tensile specimen. You would want to zero the load and then set the limits to -5N (to allow for some error due to noise in the load measurement) and +50N to set our max preload. Then, you would drop the specimen into the grips and jog in tension at a reasonable rate (5-10um/sec for a metal). The system would move the grips until 50N is hit in tension, and then command the motor to stop going in tension. Note that you may still jog in compression and reduce load, and then as long as the load is under the setup limit you may jog in tension again.

As soon as our test starts, the setup limits will be inactive and only system or safety limits will apply.

Safety limits refer to user-set limits that will cause the actuator to disable itself immediately upon the sensor reaching that value. These are active at all times that the system is running and the “enable limits” button is pressed. In addition to these safety limits, there are system limits that are set by Psylotech at the factory. These are always active regardless of the “enable limits” button. The more restrictive of the safety and system limits will be used as the disabling limit.

The second tab – mechanical setup – is used to prepare the sample for the test. Figure 4.4 shows the elements of this screen. On this screen you will select the sensor that you will be using as you prepare the specimen for mechanical testing.

Using the chart you can monitor displacement or load as you move the cross-

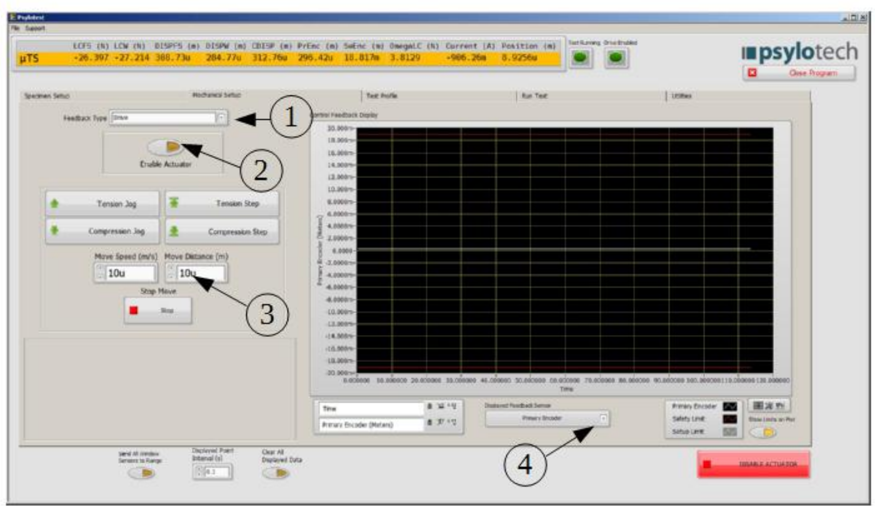


Figure 4.4 Mechanical Setup Tab: 1. Control Feedback Selection, 2. Enable Actuator, 3. Jog Speed and Step Distance, 4. Displayed Sensor Selection

head to pre-load the sample. You can use the “Jogging Controls” to move the cross-head. If you are in drive/encoder control, you can also use the (optional) jog pendant to move the cross-head. When you will be using the windowed global displacement or load control use this screen to pre-load the sample so that the test will run within the window range. If the window shifts during a test, there may be a discontinuity in the load or displacement. Window shifting can be done physically with the front panel knob or via the window shifting settings tab.

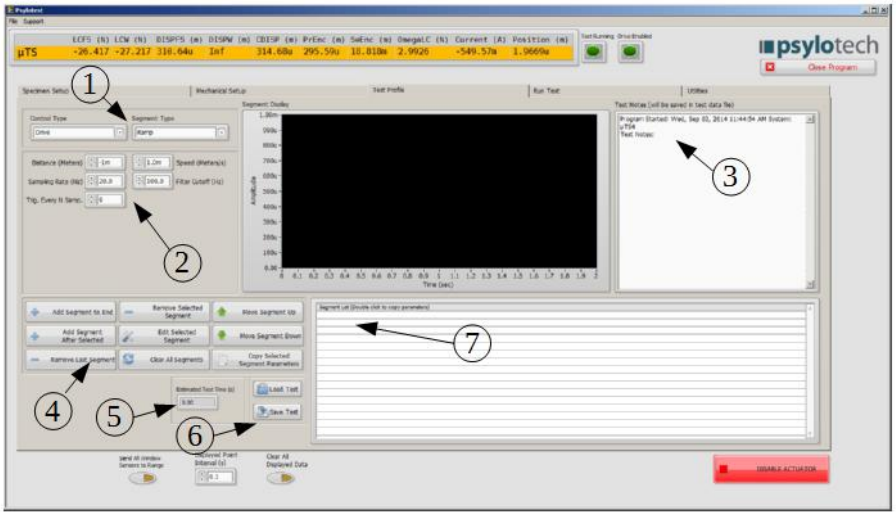


Figure 4.5 Test Profile Tab: 1. Feedback Sensor and Segment Type Selection, 2. Segment Parameter Entries, 3. User Notes, 4. Add and Remove Segment Buttons, 5. Estimated Test Time Indicator, 6. Save and Load Segment Profile to Disk, 7. List of Stages in Test Profile and Re-Ordering Controls

The test that you will be performing is entered in the Test Profile Tab (Fig. 4.5). The type of control (displacement, motor encoder and load cell and the type of profile, hold, ramp, sine, etc.) are entered on this screen one segment at a time. The “window” option is given for sensors that interface through the Psylotech Test Hub. The window improves the resolution of the sensor.

The segments are all relative to the previous segment ending value. Once segments are added the Segment Profile Plot will be populated along with the Segment List (Fig. 4.6)

Segments including hundreds of sine cycles may not display fully in order to conserve memory – however the exact parameters that are entered will be executed during the test.

4.2.1 Actuator Control Types

The type of control is selected in the Control Type window. There are three basic types of control: encoder (drive), displacement, and load.

Encoder Speed control uses the direct feedback from the motor encoder to control your experiment. Test using Encoder control can not have stages using analog feedback. Encoder tests also have a 65 second time limit per segment and can only perform step or hold moves.

Global Displacement control uses the Psylotech displacement sensor feedback to control the displacement of the cross-head during the test. This sensor also has the window option to enable better resolution of the test. If you are having trouble controlling a test in full scale displacement control, then try running the test in window mode.

Load control uses the load cell feedback to control the test. If a Psylotech load cell is installed in the system Load Window control may be used to get better load resolution for your test.

4.2.2 Segment Shape Type

The test segment type selection sets the way that the load, speed or displacement is applied to the specimen. The parameters for each segment are set in Cycles, Amplitude, Frequency, Start Phase, Duty Cycle, etc. Only parameters which apply to the particular type of profile are available.

Hold keeps the controlled variable constant for a period of time.

Ramp increases or decreases the variable linearly over a period of time.

Sine applies the load or displacement as a sine wave.

Square applies the load or displacement as a square wave. Set the duty cycle at 50% if you want the shape to be truly square.

Triangle applies the load or displacement in a triangle wave.

Sawtooth applies a half triangle and half square type wave.

The segment is added to the test regime by clicking the "ADD SEGMENT" button. The segment will appear on the Test Profile Diagram

The segment may be re-ordered or removed. Click on the desired segment in the segment list. The corresponding profile of that segment will be highlighted for a visual reminder of which segment is selected. Press the “REMOVE SEGMENT” or “MOVE SEGMENT UP” or “MOVE SEGMENT DOWN” buttons to remove or re-order the segments.

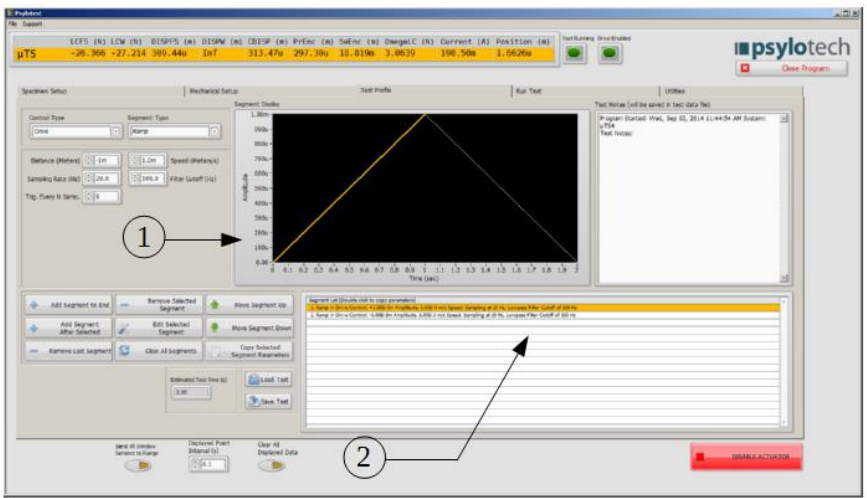


Figure 4.6 Test Profile Tab: 1. Segment Preview Plot, 2. Segment List with Selected Segment Highlighted in List and on Plot

All segments may be cleared by pressing the REMOVE ALL SEGMENTS button

A segment's parameters may be copied to the parameter inputs by double clicking it in the Segment List or by clicking the “Copy Selected Segment Parameters” button.

If desired, a segment may be edited in place by first double clicking it in the Segment List, then editing the necessary parameters, and then clicking “Edit Selected Segment.”

The segment profile may be saved to file for later use. Press the “SAVE TEST” or “LOAD TEST” buttons to perform these actions.

Running the test and saving the data to a file is done on the Run Test Tab (Fig. 4.7). Prior to running the test you must set the file path and file name for the test. Select variables that will be displayed on the Variable Display. Also select the material property that you would like to display. Please note the Stress vs. Strain is calculated based on the samples sizes entered on the Specimen Setup Tab.

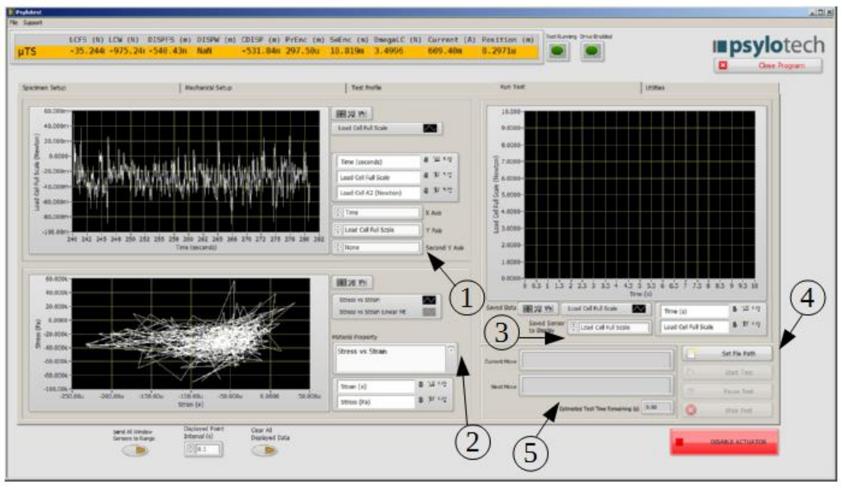


Figure 4.7 Run Test Tab: 1. Select Variables to display, 2. Select Material Property to display, 3. Select Sensor to Display of Saved Data, 4. Set File Path, Start and Pause Test Buttons, 5. Current Move, Next Move, and Estimated Time Remaining Indicators

When the test starts the Saved Data Plot will populate every few seconds with data at the actual sampling frequency selected for that ramp. This is useful to preview the data getting saved to file and ensuring that the sample rate is fast enough to capture the events that are interesting.

Also displayed are the current and next move in the test profile. This is useful to see which segment is active in the motion controller. Provided next to these displays is the estimated time remaining in the test. While only an estimate, it provides a good sense of how long the test has left.The Utilities Tab is used to change the controller tuning, window shifting options, and limit resetting among other things. Many of the functions on the Utilities Tab should only be used by experienced users. Please see Section 10 for the utility function explanations.

5 Quick Start Test Guide

5.1 Sample preparation

Prepare your sample with respect to the grips and imaging technique desired. Each Psylotech grip has a manual which can be referenced separately. Each magnification of the imaging system will require different techniques for proper measurement of strain under DIC. Refer to the technical notes provided by the DIC software provider to more information.

5.2 Open the Psylotest Software

Before inserting the specimen, zero the load and enter the specimen dimensions

Set the limits to reasonable values for the test. If it is a tension test a good range is from -10 Newtons to +2000 Newtons or a load that is expected as the maximum.

5.3 Mechanical Setup

Determine the type of test desired (encoder control, displacement control, or load control).

Enable the actuator in encoder control to allow the jog buttons on the interface as well as the jog buttons on the optional jog pendant to move the crosshead into a location that suits the grip spacing and specimen length.

The fixed crosshead may need to be moved (except in the case of the nTS, where it is fixed) in order to accommodate the specimen length or the imaging system's location requirements. In order to do this, loosen all 4 or 6 bolts that clamp the fixed crosshead assembly to the support shafts. Smoothly and axially slide the fixed crosshead, minding the load cell cable, until the crosshead is in the desired position. Re-tighten the bolts; for the 1.6kN frame, the 4 bolts must be tightened to at least 5 N-m. For the 10kN frame, the 6 bolts must be tightened to at least 9 N-m. The torque on these bolts is imperative as they are responsible for applying the friction that holds all of the load on the load cell during a test.

Load the specimen and apply enough load to hold it in place.

If an encoder control test is desired, the actuator may be left in encoder control. If a load or displacement control test is desired the system needs to be enabled in one of those modes. The system cannot change between encoder control and any other type of control without disabling the actuator first. **Before enabling the system in load control be sure that the specimen is inserted and the load train is ready to accept load.**

5.4 Creating the Test Profile

Create the test profile and enter any notes or test parameters that you would like included in the data file. Speed is directionless while distance or amplitude incorporates the direction. Section 4.2.2 of this manual describes the different test profiles that are available in this program. Once the test stages have been entered the file path is ready to be set. Remember to set any specific notes to distinguish the specimen used in the test.

5.5 Running a Test

The test data will be written to a tab separated file. You need to set the file path prior to running a test. The file will automatically be set to a .txt file, and the data will be output in tab separated format. The header of the file will include the date and time of the test, the specimen dimensions, any notes entered, the test segments, and the data. Once the file path has been set click the Start Test button, and the test will begin.

Start image acquisition on the separate image acquisition computer a few seconds before starting the test in Psylotest in order to capture all of the test within the images.

If the test needs to be stopped or paused, the buttons on the bottom right of the Run Test tab may be used.

When the test is over, the Test Running indicator on the top of the screen will go out.

6 System Specifics

6.1 µTS

The default configuration of the µTS has a nominal load range of 1.6kN and has a 25mm stroke with Windowed position and Windowed load sensors. The frame may be built up to 2kN with added options. It may also be configured to handle environmental vacuum, high vacuum, and ultraviolet (UV) light exposure conditions.

NOTE: For customized systems, please reference appendix.

6.1.1 Dimensions

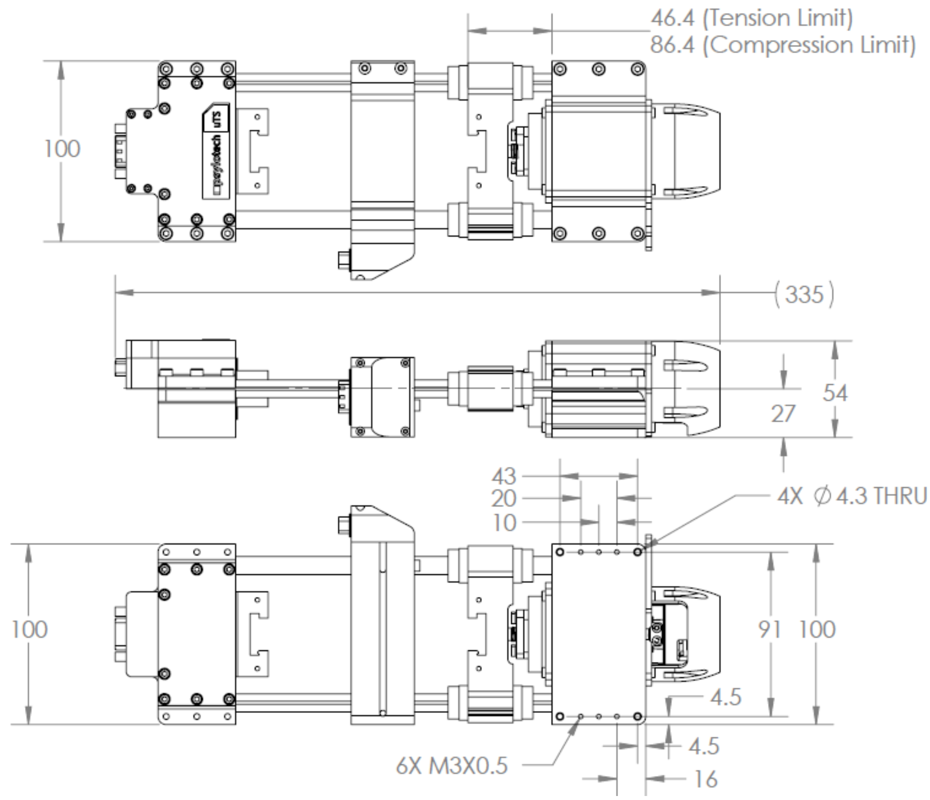


Figure 6.1 μTS Frame Dimensions

The load frame has a volume of approximately 334x100x54mm, and a mass of 2 kg. When not using the secondary stage (see section 6.1.4) the center of the specimen rests at a height of 27mm from the bottom of the frame.

With a windowing displacement sensor, the 8mm stroke full scale range has 100 nm resolution, with expected standard deviation noise of 2μm and each +/- 80 micron window has 1nm resolution with expected standard deviation of noise to be 20nm.

The 1.6kN Psylotech windowing load cell has a full scale load range of +/- 1.6kN with a full scale resolution of 50mN and expected standard deviation of noise of .8N. Each 32N window has a resolution of 500μN and expected standard deviation of noise under 500Hz of 8 mN.

A +/- 100N load cell is also available, in addition to other custom ranges.

6.1.2 Optional Local Displacement Sensor

The clamp on displacement sensor allows for removing much of the system compliance for more accurate global strain measurements. It can be positioned anywhere between the crosshead and load cell, and has a range of +/- 5mm starting from 2mm away from the mechanical limit on the crosshead side.

For best results, avoid tests where the crosshead may ram the displacement sensor at high speed.

6.1.3 Grips

6.1.3.1 Tension Dogbone Grip

Using the dogbone grip (Fig. 6.2) and carefully aligning the center of the specimen to the load train allows for the best results for microscopy. The specimen will stay as in plane as possible aside from Poisson's effects.

If the specimen has a thickness less than 12mm (grip height) shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 6-(specimen thickness/2).

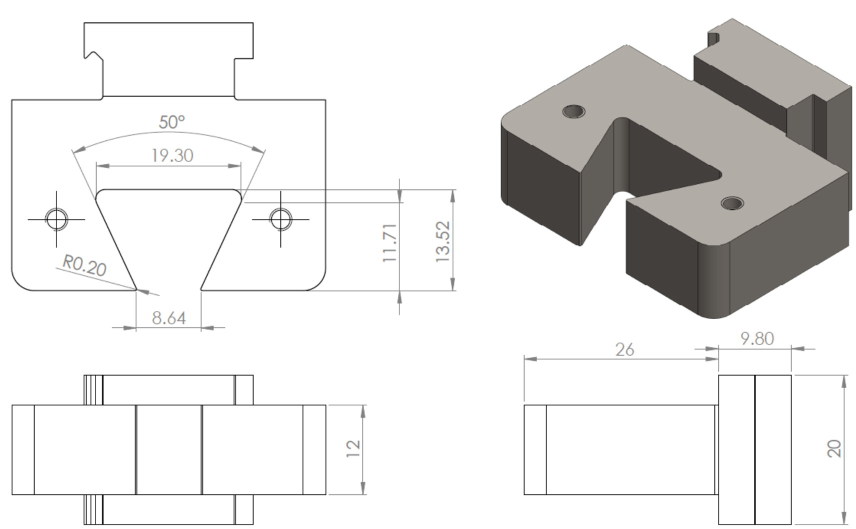


Figure 6.2 µTS Tension Dogbone Grip and Specimen Dimensions

6.1.3.2 Tension Clamp Grip

The clamp grip is meant for pulling on specimens that are not capable of being held by the dogbone grip. These may be soft specimens of ones that don't fit into the dogbone structure. These grips are more flexible for tensile tests but generally do not perform as well under high magnification.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from top of the crosshead to the top of the grip (mm) = (specimen thickness/2)

See Figure 6.3 for mounting dimensions and specimen size parameters.

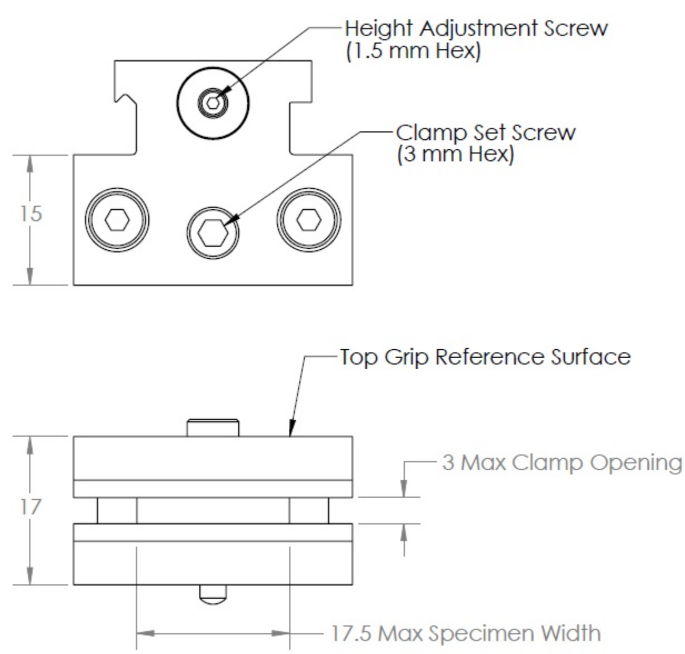


Figure 6.3 µTS Tension Clamp Grip

6.1.3.3 Compression Platen

The compression platens are meant solely for compressive loading.

Mounting and position the specimen on axis will provide more reliable and accurate data.

If the specimen has a thickness less than 4mm (platen height) shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 2 – (specimen thickness/2)

See Figure 6.4 for more information regarding the µTS compression grips.

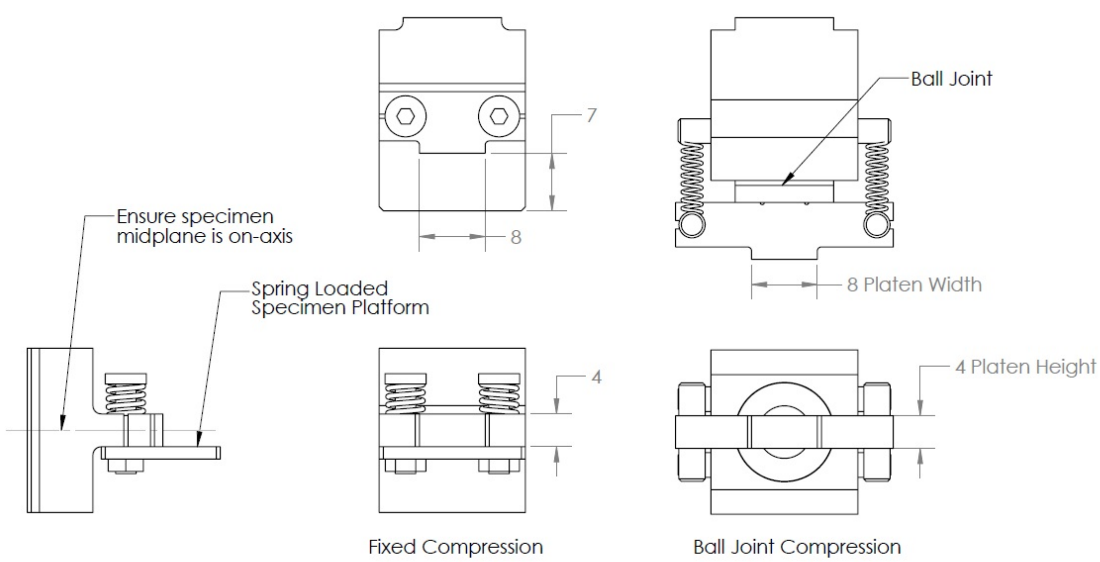


Figure 6.4 µTS Compression Grips

6.1.3.4 Platform Grip

The platform grips are designed to be the foundation of a host of other experimental techniques. With a grid array of tapped holes, these grips are suited to mounting any other type of grip module to them.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from the top of the crosshead to the top of the grip (mm) = 1.5 + (specimen thickness/2)

See Figure 6.5 for mounting information regarding the platform grip.

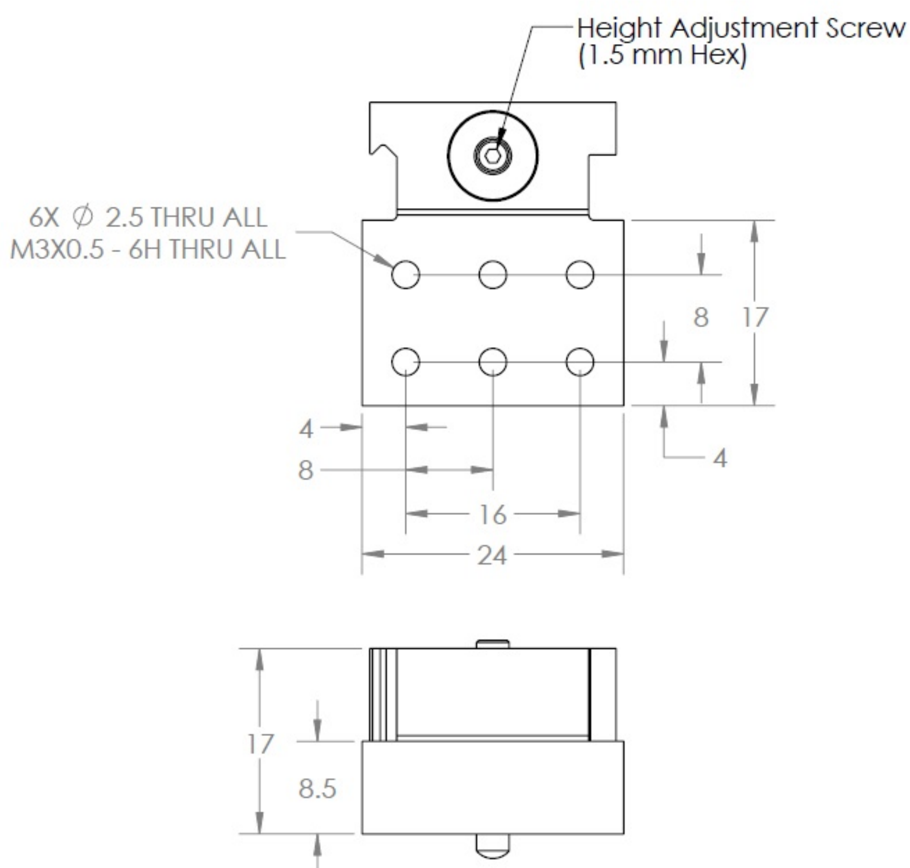


Figure 6.5 µTS Platform Grip

6.1.3.5 Arcan Grips

The Arcan grip is useful for measuring tension, pure shear, and mixed tension/shear loading of a specimen. It is a good way to achieve a multi-axis stress state from a uni-axial loading.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from top of crosshead to top of grip (mm) = 4.1mm + (specimen thickness/2)

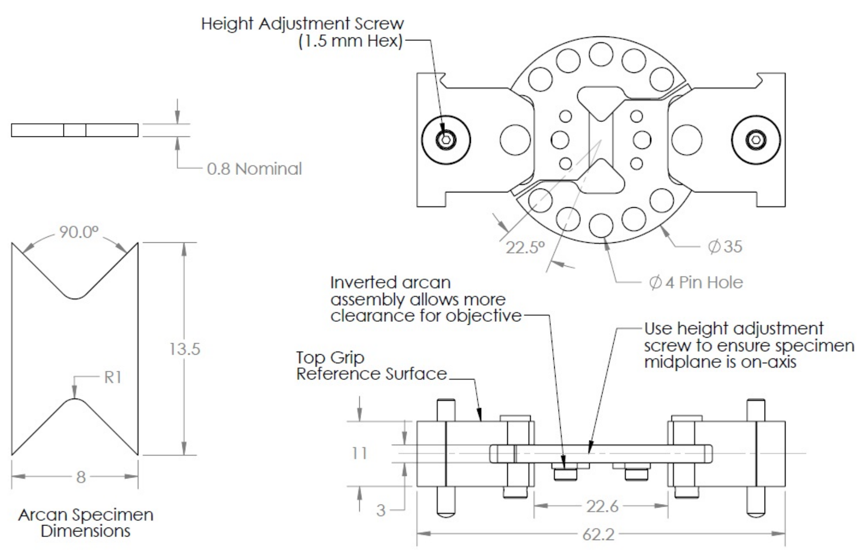


Figure 6.6 μTS Arcan Grip and Specimen Dimensions

See Figures 6.6, 6.7, and 6.8 for more information on sizing and test methods with the Arcan Grip

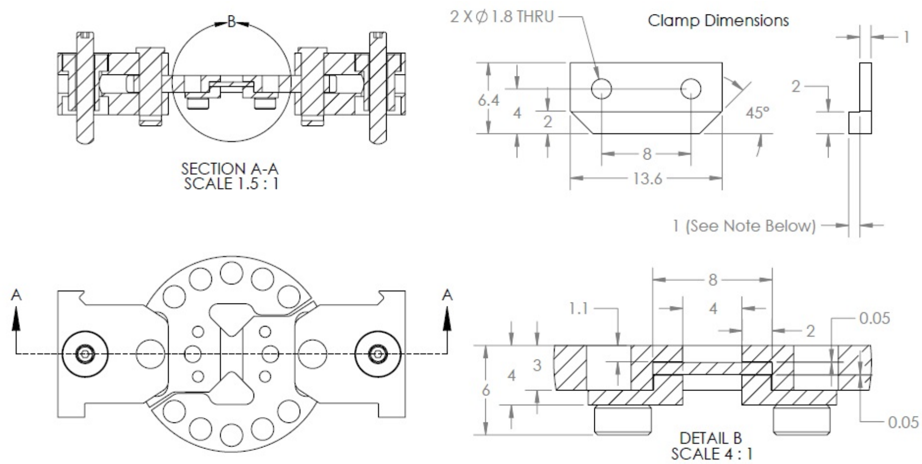


Figure 6.7 μTS Arcan Grip Assembly

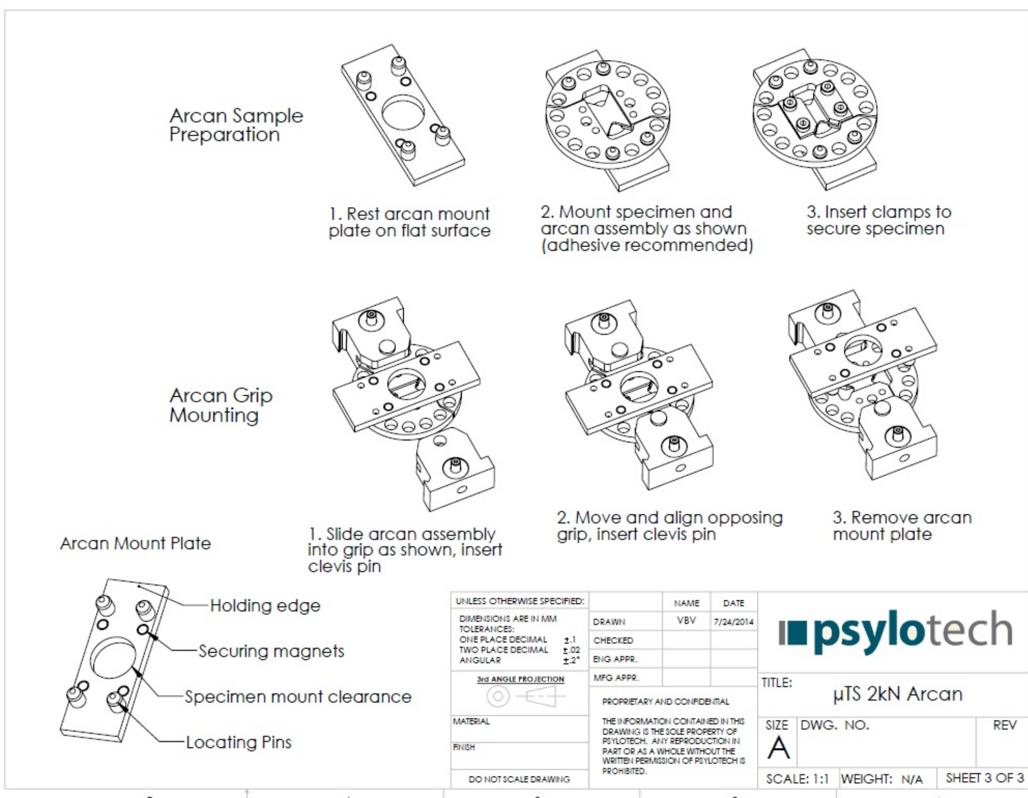


Figure 6.8 μTS Arcan Grip Guide

6.1.3.6 Bending Grips

The bending grips are meant to apply single or multiple point bend loads on specimens.

Mounting and positioning the specimen on axis will provide more reliable and accurate data.

If the specimen has a width less than 12mm, shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 4 – (specimen thickness/2)

See Figure 6.9 for more information regarding the µTS system's bending grips.

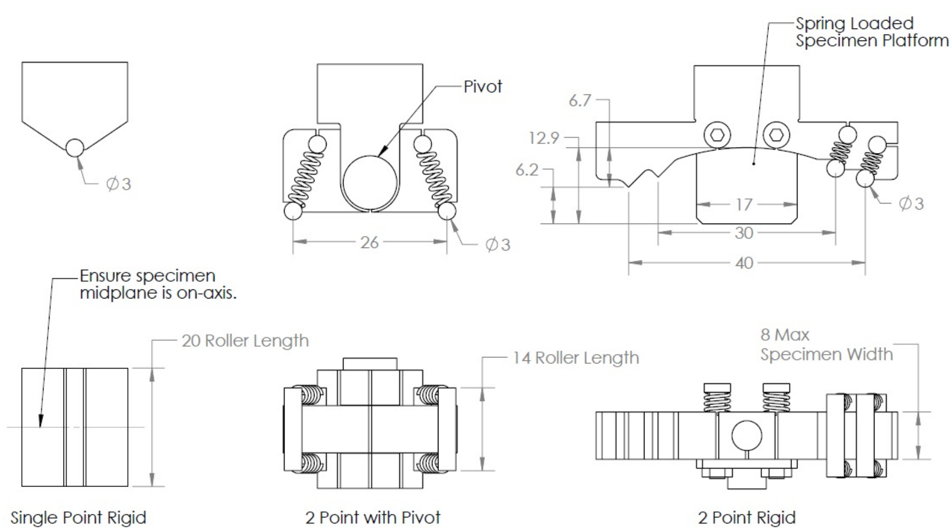


Figure 6.9 µTS Bending Grip Dimensions

6.1.4 Secondary Stage

The secondary stage for the μTS frame has an approximate 515x152mm footprint. See Figure 6.10 for dimensions. The secondary stage will add 56mm to the specimen center axis height. This brings the specimen central axis to a total height of 83mm above the working table.

When mounting the load frame to the secondary stage, use a bolt torque of 4 N-m.

The secondary stage has a travel of approximately 80mm. It is recommended to zero the primary actuator's reference to the secondary stage's zero position to ensure maximum centering capability.

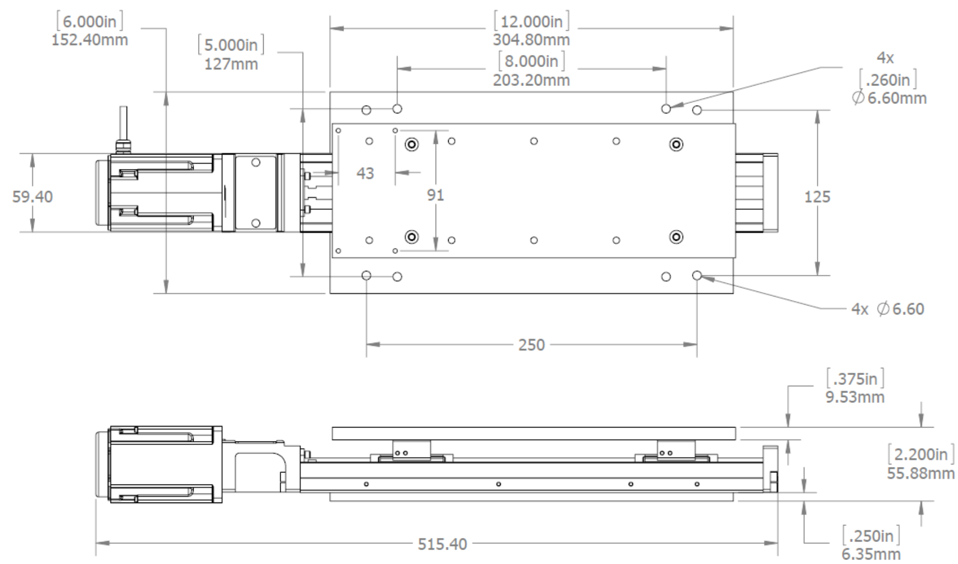


Figure 6.10 μTS Secondary Centering Stage Dimensions

6.2 µTS10

The largest of Psylotech's systems, the 10kN is significantly heavier and bigger than the other frames. It is not designed to fit inside of a vacuum chamber.

6.2.1 Dimensions

The footprint of the 10 kilonewton frame is approximately 650x200x123mm and the load train is centered at 62 mm above the mounting surface. The frame without the secondary centering stage has a mass of 23 kg. See Figure 6.11 for a frame drawing.

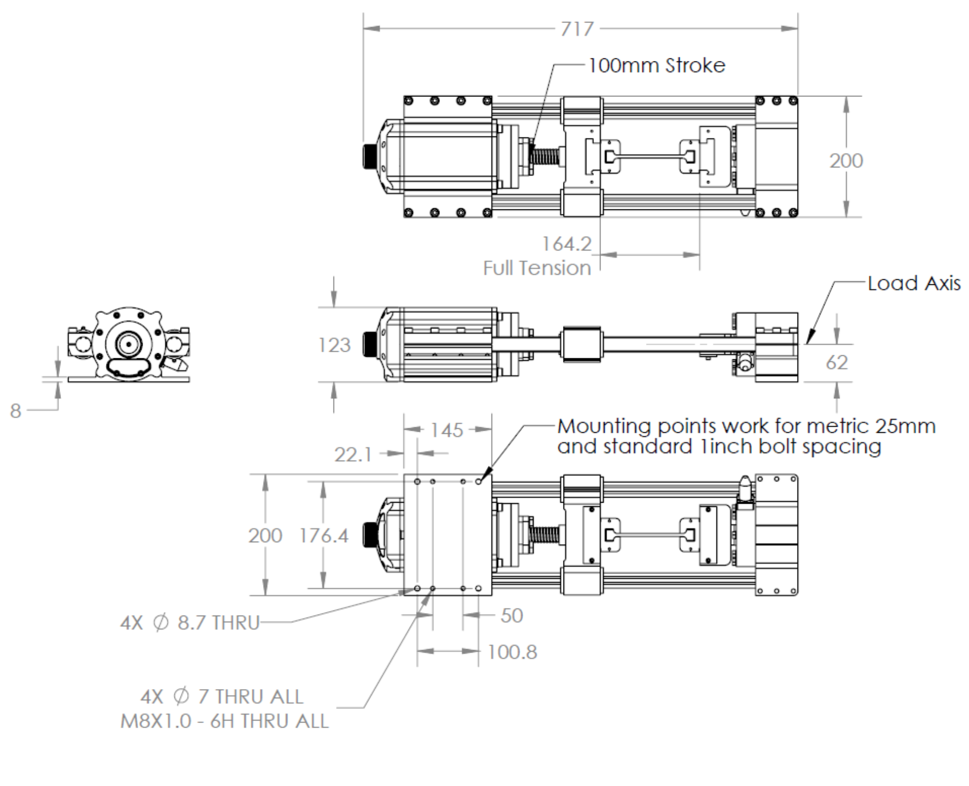


Figure 6.11 µTS10 Frame Dimensions

The system has a 100mm stroke. With a windowing displacement sensor, the 8mm stroke full scale range has 100 nm resolution, with expected standard deviation noise of 2µm and each +/- 80 micron window has 1nm resolution with expected standard deviation of noise to be 20nm.

The 10kN Psylotech windowing load cell has a full scale load range of +/-

10kN with a full scale resolution of 300mN and expected standard deviation of noise of 5N. Each 200N window has a resolution of 3mN and expected standard deviation of noise under 500Hz of 50 mN.

6.2.2 Grips

6.2.2.1 Tension Dogbone Grip

Using this grip and carefully aligning the center of the specimen to the load train allows for the best results for microscopy. The specimen will stay as in plane as possible aside from Poisson's effects.

If the specimen has a thickness less than 12mm (grip height) shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 6-(specimen thickness/2).

See Figure 6.12 for mounting dimensions and specimen dimensions on the 10kN system.

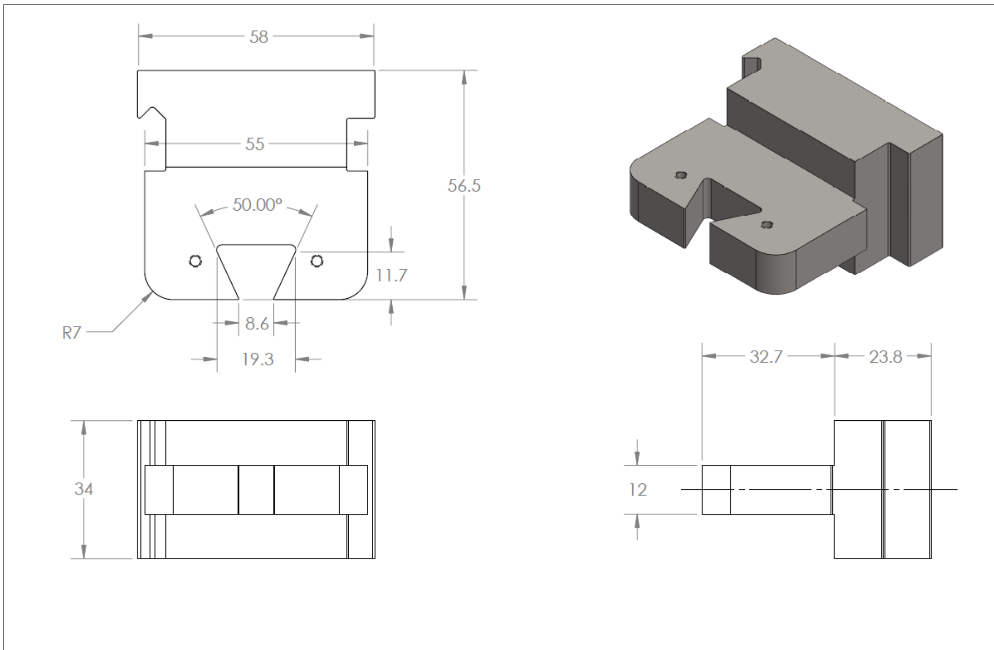


Figure 6.12 μTS10 Tension Dogbone Grip Dimensions

6.2.2.2 Tension Clamp Grip

The clamp grip is meant for pulling on specimens that are not capable of being held by the dogbone grip. These may be soft specimens of ones that don't fit into the dogbone structure. These grips are more flexible for tensile tests but generally do not perform as well under high magnification.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from top of the crosshead to the top of the grip (mm) = (specimen thickness/2)

See Figure 6.13 for mounting dimensions and specimen size parameters for the 10kN system.

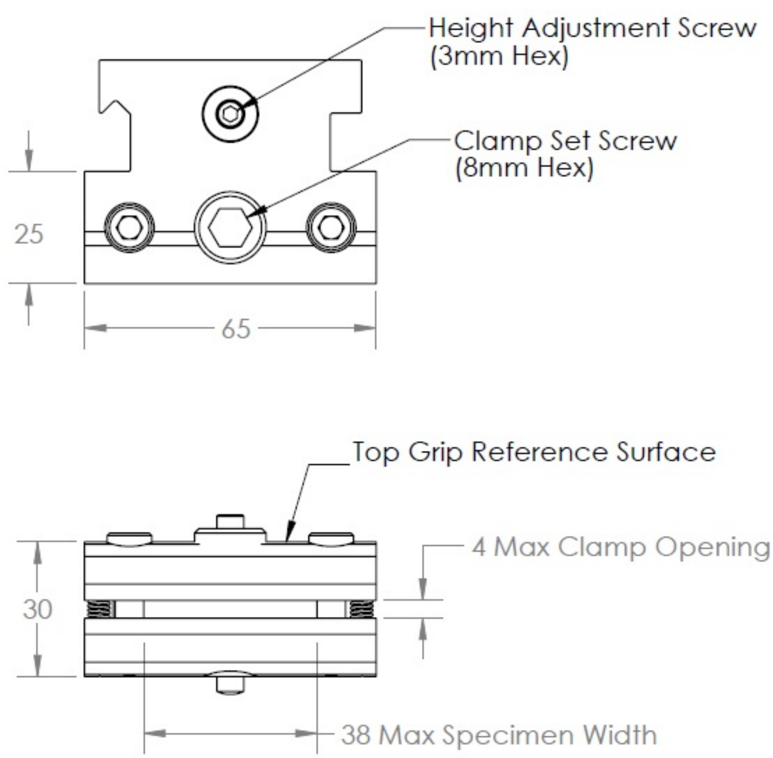


Figure 6.13 µTS10 Tension Clamp Grip

6.2.2.3 Compression Platen

The compression platens are meant solely for compressive loading.

Mounting and position the specimen on axis will provide more reliable and accurate data.

If the specimen has a thickness less than 10mm (platen height) shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 5 – (specimen thickness/2)

See Figure 6.14 for more information regarding the grip on the 10kN system.

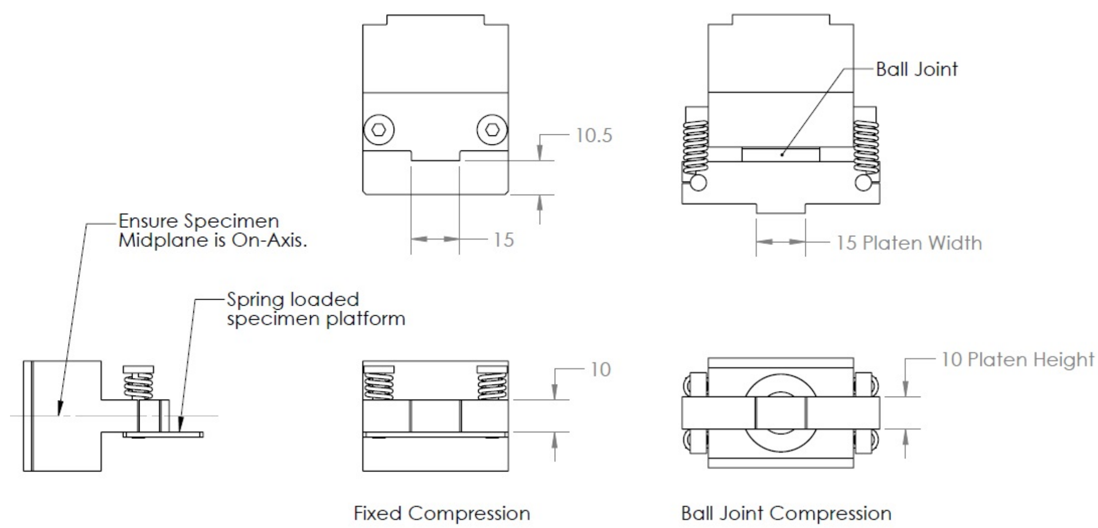


Figure 6.14 µTS10 Compression Grips

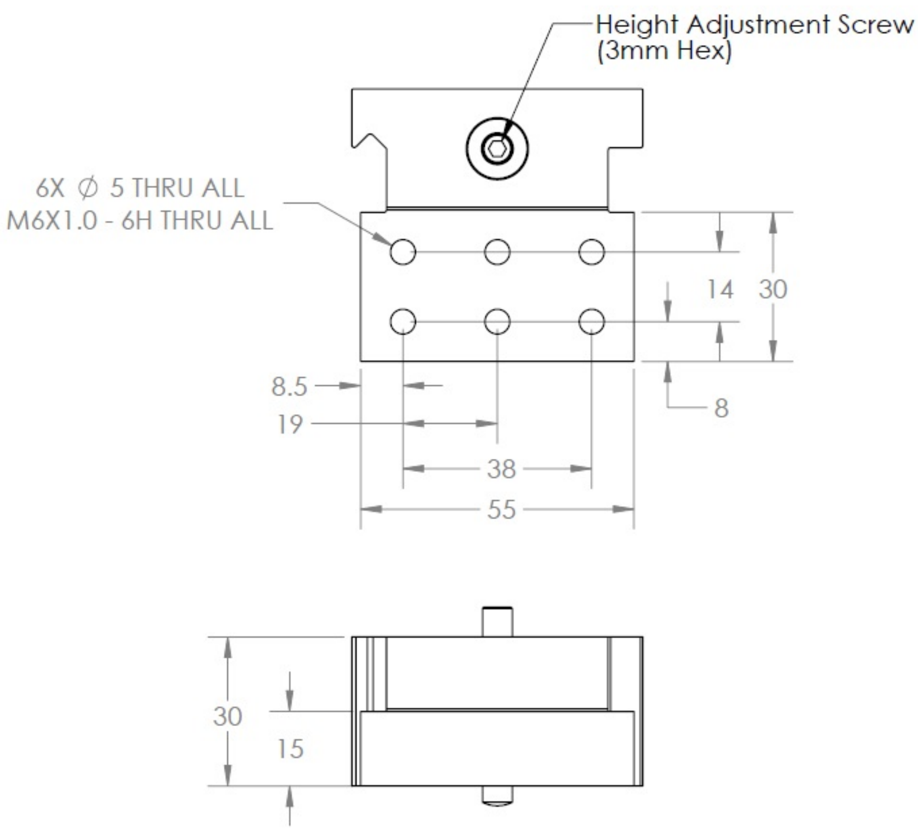
6.2.2.4 Platform Grip

The platform grips are designed to be the foundation of a host of other experimental techniques. With a grid array of tapped holes, these grips are suited to mounting any other type of grip module to them.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from the top of the crosshead to the top of the grip (mm) = 2 + (specimen thickness/2)

See Figure 6.15 for mounting information regarding the 10kN platform grip.



6.2.2.5

Figure 6.15 µTS10 Platform Grip

6.2.2.6 Arcan Grips

The Arcan grip is useful for measuring tension, pure shear, and mixed tension/shear loading of a specimen. It is a good way to achieve a multi-axis stress state from a uni-axial loading.

Mounting and positioning the specimen on axis will provide more reliable and accurate data. Calipers can be used to verify specimen placement by measuring the distance between the top surface of the crosshead and the top surface of the grip.

Distance from top of crosshead to top of grip (mm) = 1.6 + (specimen thickness/2)

See Figure 6.16 for more information on sizing and test methods with the 10kN Arcan Grip

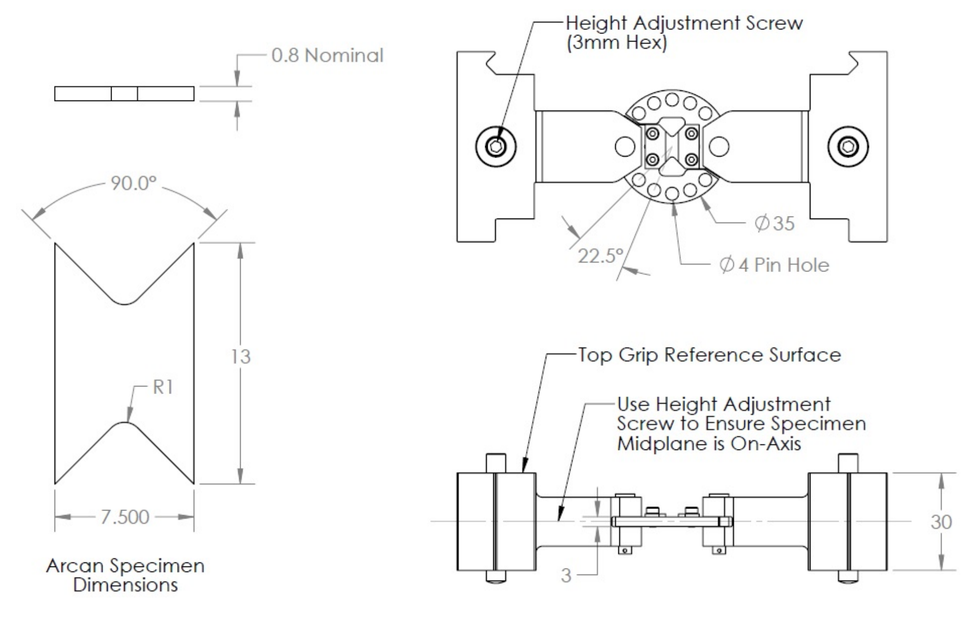


Figure 6.16 µTS10 Arcan Grip and Specimen Dimensions

6.2.2.7 Bending Grips

The bending grips are meant to apply single or multiple point bend loads on specimens.

Mounting and positioning the specimen on axis will provide more reliable and accurate data.

If the specimen has a width less than 12mm, shims can be placed beneath the specimen on the specimen platform in order to ensure on-axis specimen placement.

Shim thickness (mm) = 6 – (specimen thickness/2)

See Figure 6.17 for more information regarding the 10kN system's bending grips.

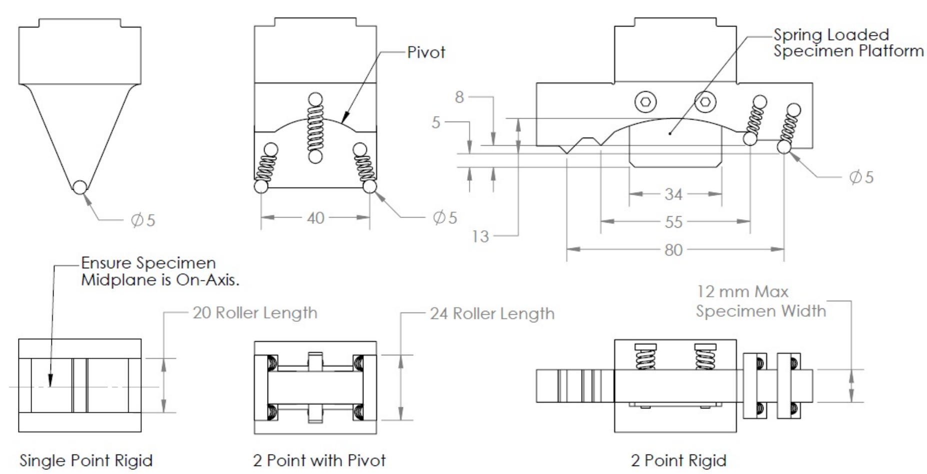


Figure 6.17 µTS10 Bending Grip Dimensions

6.2.3 Secondary Stage

The secondary stage for the 10 kilonewton frame has an approximate 790x200mm footprint. See Figure 6.18 for dimensions. With the secondary stage, the total system has approximately 36 kg mass and will add 59.5mm to the specimen center axis height. This brings the specimen to a total height of 121.5mm. When mounting the load frame to the secondary stage, use a bolt torque of at least 5 N-m.

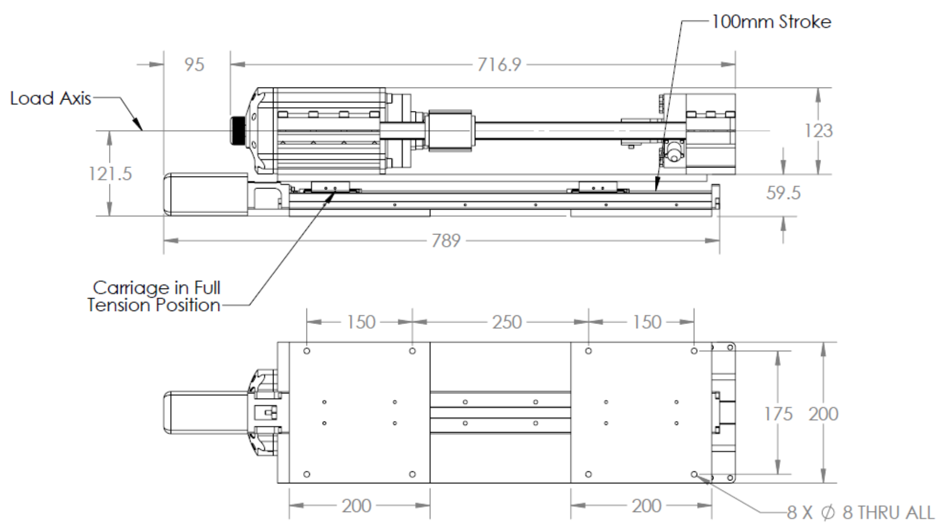


Figure 6.18 µTS10 Secondary Centering Stage Dimensions

7 Secondary Centering Stage

7.1 Usage

The secondary stage (Fig 7.1) is meant to keep the objective of a fixed position microscope centered over the same place on a specimen. This is useful when the rigid body motion of the specimen due to high strains causes the area of interest to move out of the field of view.

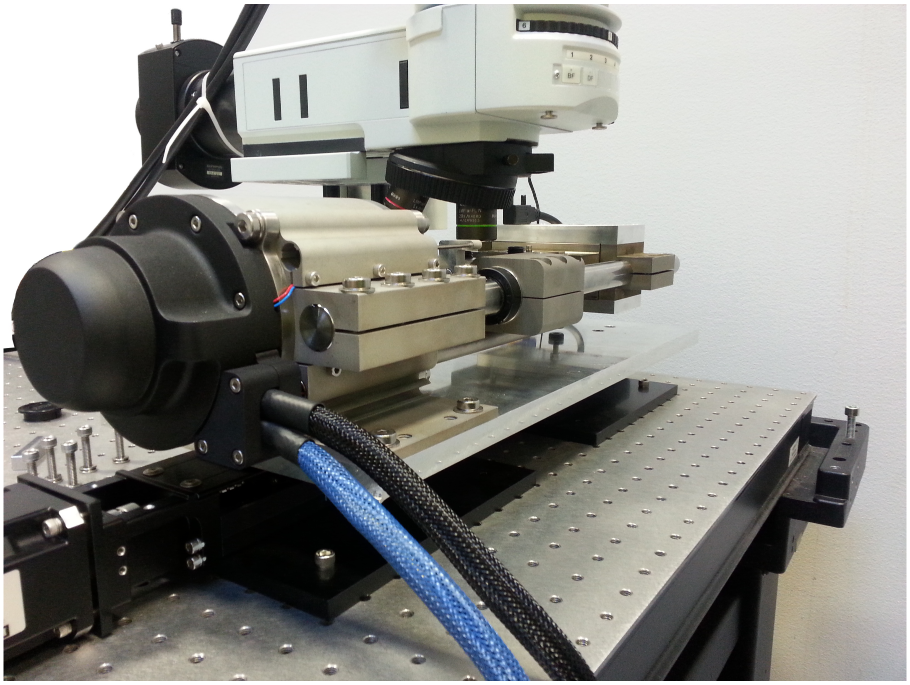


Figure 7.1 10kN Secondary Centering Stage with Frame

If the system in use is equipped with a secondary stage, extra controls will appear on the Mechanical Setup Tab (Fig 7.2).

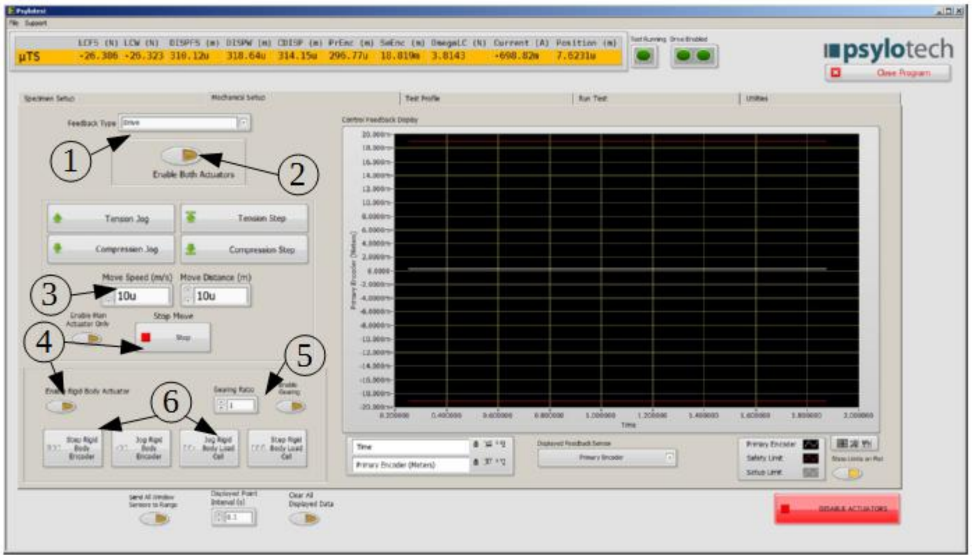


Figure 7.2 Secondary Stage Controls: 1. Feedback Type applies to Primary Stage. Secondary Stage is always either Drive feedback or Gearing Feedback 2. Enable both actuators button 3. Move distance and speeds apply to both actuators 4. Separate Enable buttons for selective enabling of the secondary stage. When not in use, it is recommended that it be left disabled 5. Gearing ratio control and enable gearing button 6. Jog and step controls for the secondary stage

A user may enable the primary actuator, secondary actuator, or both if desired. If both stages are enabled and the gearing option is set then any movement in tension or compression on the main actuator will be seen at the desired gearing ratio on the secondary stage with the intention of keeping the specimen centered under the microscope.

To ensure that the gearing is in effect during a test, the secondary actuator must be enabled and gearing must be set on it for it to receive the commands to move.

7.2 Gearing Ratio

To calculate the gearing ratio, the location of the center field of view relative to the fixed side of the primary actuator must be measured; call this x0. In addition, the gauge length or grip to grip distance must be known (call this L0). The gearing ratio is then calculated as L0/x0.

The secondary stage may also be moved independently when not in gearing mode to provide rigid body x-direction translation of a specimen under test.

In order to keep the specimen in the field of view at very high magnification, the speed of the secondary stage is limited to approximately 1mm/second while gearing is enabled.

Mount the load frame to the secondary stage using the bolts mentioned in the drawings for each load frame, Section 6. They should be tightened to the correct torque specification, also mentioned in the System Specifics section.

8 Jog Pendant

The jog pendant is an optional add on that provides a convenient ability to jog, step, and stop the system remotely from the control PC. If the system is mounted on a microscope table that is not directly next to the control PC then it can be cumbersome to move the actuator.

With the jog pendant, a user can "jog" the moving crosshead continuously in either tension or compression directions or step discrete small increments in either tension or compression directions.

The jog pendant only works when the actuator is enabled and the control type is "Drive."

Another feature of the jog pendant is the safety stop switch. This is a push on, twist off type switch that will stop the actuator upon pressing. In order to re-enable the actuator, the switch must be twisted so that it resets.

If a jog pendant is available on the system being used, it must be plugged in so that the stop switch is recognized by the software.

See Figure 8.1 for an image of the jog pendant.

Figure 8.1 Jog Pendant

9 Triggering

In addition to adding an extra control parameter when setting up a test segment (See Fig. 4.5), extra hardware will be installed to allow for this feature. The termination is a BNC output on the front panel of the Test Hub.

The trigger function allows a user to send out a transistor-transistor logic (TTL) level signal (high voltage = 5 Volts) at up to 500Hz at the same time a sample is saved in the Psylotest controller. Each trigger that is saved is numbered in an extra column corresponding to the sample that was taken closest to it (within 2ms). This can be useful for triggering imaging systems either through a direct interface to a camera or through a DAQ interface on a separate computer to the imaging software.

To add a trigger to a given segment, the user would simply enter a value for "Trig. Every Nth Samp." on the segment setup page. A trigger may be set every sample, or every 2nd sample, etc. up to 500Hz.

To get more information regarding this feature and how it can be retrofitted to your system (if not already installed) please call Psylotech sales at 847-328-7100 or info@psylotech.com.

10 Software Utility Functions

Utility functions are meant for advanced use or auxiliary control that is not necessarily needed for everyday testing. The various features are described below.

10.1 Window Shifting

Psylotech's proprietary “Windowing” sensors are able to show much more resolution for a discrete small (1/100th of full scale) range. In order to change which area of the full scale range that the sensor is zoomed into the window must be shifted.

This can be done with either the knobs on the right side of the front panel of the sensor or can be done via the first leftmost tab on the utilities page (Fig 10.1). Each sensor that has a window associated with it is listed. The autoshifting feature keeps the window within range using commands from the software and a stepper motor that physically moves the knob on the front panel. The locked indicator tells the user whether or not the sensor is within a valid window range.

To the right of the “Window Shifting” tab there are some controls for manually shifting the window remotely. Select the desired sensor to shift and click the shift up or shift down buttons to move the window. When performing a test that is only in tension for instance it may be useful to start the window near the bottom of its range so that the maximum range of the window is available for the test. This can also be done using the position drop down and sending the sensor to that position.

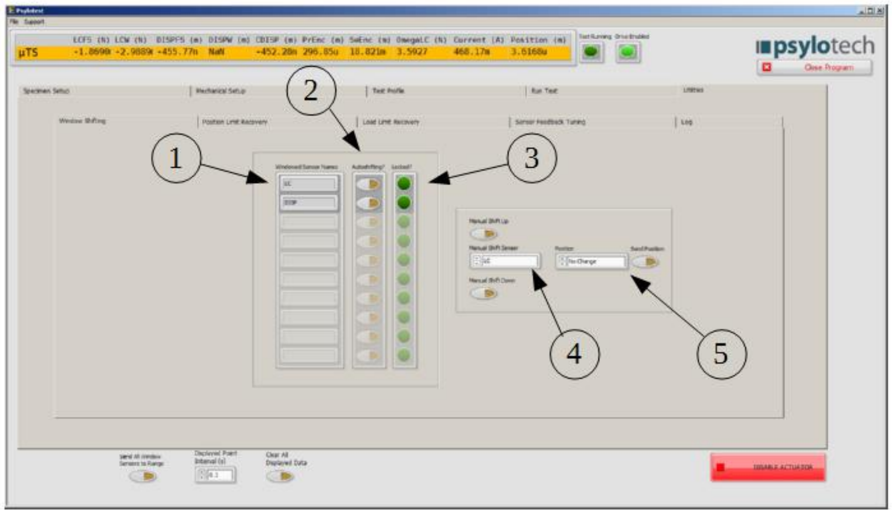


Figure 10.1, Window Shifting Utility: 1. Window Sensor List, 2. Autoshifting Controls, 3. Locked Sensor Indicators, 4. Manual Shift Controls, 5. Specific Position Controls

10.2 Position Limit Recovery

The second tab on the utilities page allows for the recovery of a tripped position limit (Fig 10.2). Sometimes the actuator will not allow itself to enable if it is past a limit that it should not have traveled past. Simply click the button on this tab and the system will enable itself and move back to be barely inside a usable region. Beware that the limits are temporarily disabled to allow the actuator to move back; make sure that all sensitive components or bodily parts are clear of the actuator.

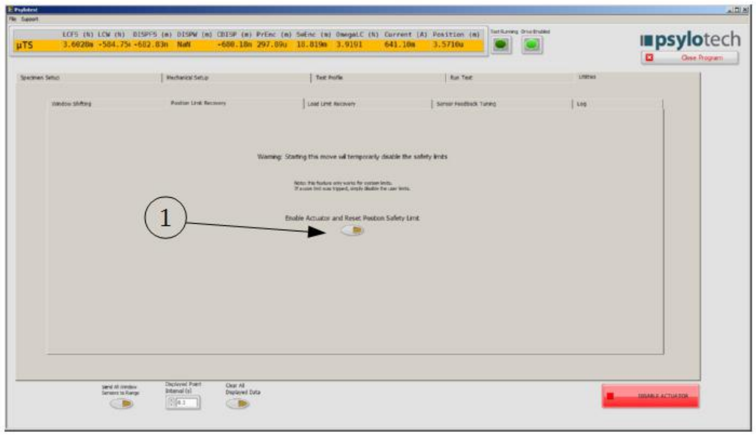


Figure 10.2, Reset Internal Position Limit Utility: 1. Reset Limit Button

10.3 Load Limit Recovery

Similar to the position limit recovery above, load limit recovery is useful when a system load limit is tripped. The actuator will normally not enable itself if the load is past the range; however, by setting a small distance and speed in this utility tab and pressing the Reset button you can. The limits are temporarily disabled and the actuator is moved to a suitable position. See Figure 6.1 for an image of this utility page.

Most load frames will relax enough after the actuator is disabled that the load goes well under the system load limit.

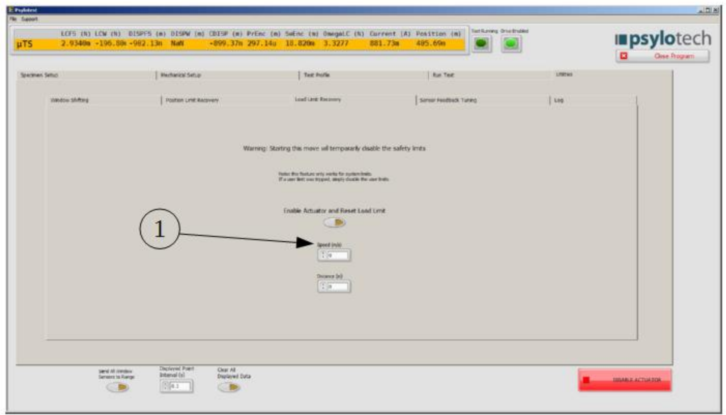


Figure 10.3, Reset System Load Limit Utility: 1. Reset Limit Button, Speed, and Distance controls

10.4 Sensor Feedback Tuning

The system is tuned to perform very well at slow speeds and mid ranges since that is the majority of use of the frame. However, some users may find that they need a bit extra speed at the expense of stability. The sensor feedback tuning tab is where the tuning parameters of each sensor can be modified. Keep in mind this is for advanced users only. There are also tuning parameters inside of the servo drive that need to be considered. See Figure 10.4 for annotation.

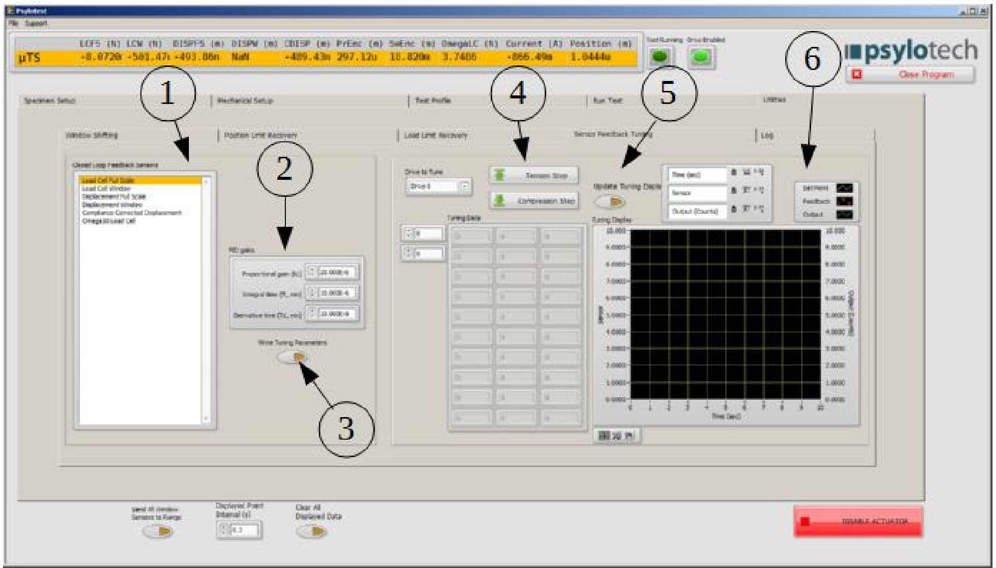


Figure 10.4, PID Motion Control Tuning: 1.Selection of Sensor to Tune, 2. Sensor PID Gains, 3. Commit Tuning Parameters to the Controller, 4. Cause a Step Motion (Defined on the Mechanical Setup Tab), 5. Toggle to Allow Tuning Data and Plot Updates –Keep Off While System is in Use, 6. Tuning Data Plot

10.5 Log

The log (Fig 10.5) contains information pertaining to system events. Some events are useful information about system status and some are more serious. For example, if the actuator disables unexpectedly the reason will be printed here (the top of the list is the most recently received log message).

If a sensor is being controlled and it goes out of its range the actuator will disable itself. This will generate a log event that the user can view and see which sensor tripped to help better design the experiment to maintain the values under the limits.

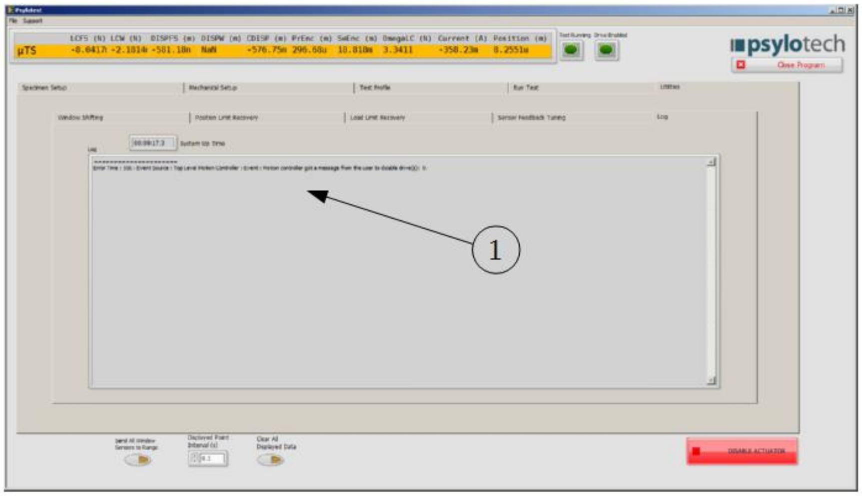


Figure 10.5, Log: 1. List of Log Entries Chronologically from Most Recent at Top to Least Recent at Bottom

11 Maintenance and Troubleshooting

11.1 Actuator Doesn't Enable

The most common cause of the actuator failing to enable is a sensor being beyond its designed limit, or the emergency stop switch being depressed or not plugged in. When the actuator fails to enable, or disables unexpectedly, the first place to look for the reason is in the Utilities tab. There is a Log tab within the Utilities that displays a log of events affecting the actuator (See section 10.5 for more information).

11.2 Replacing Grips

The grips slide on the t-slot on the stationary and moving cross-heads. They are held in place by magnets.

11.3 Lubricating Ball-screw

No grease or oil needs to applied to the ball-screw. Once a month the ball-screw should be cleaned with alcohol and wiped with a dry soft lint free cloth. Move the cross-head from one end of its travel to the other end to make sure the ball bearings are re-oriented.

Dust and dirt will damage the ball-screw. Remove dust and dirt if you notice any on the ball-screw.

11.4 Lubricating Linear Guides

No grease or oil needs to be applied to stainless steel linear guides. Once a month the linear guides should be cleaned with alcohol and wiped with a dry soft lint free cloth. Move the cross-head from one end of its travel to the other end to make sure the ball bearings are re-oriented. For steel type linear guides, "WD-40 Specialist Long-Term Corrosion Inhibitor" should be applied routinely as directed by the product.

Dust and dirt will damage the ball-screw. Remove dust and dirt if you notice any on the ball-screw.

11.5 Limit Switches

Software based limit positions are set at the limits of travel of the cross-head. The stop positions are designed to stop the servo-motor before any damage is done to the test frame; However, the clamp-on displacement sensor has no indicator that will stop the crosshead from hitting it. For best results, avoid test conditions that will cause the actuator to hit the displacement sensor.

11.6 Calibration

Calibration should only be done by a qualified person. Call Psylotech and arrange for a service call.

11.7 Software Backup

A DVD is included with drivers and Psylotest software in case it needs to be reloaded on the computer. The Windows 7 product key or support code is located on the computer case.

11.8 Test Doesn't Start

If the test does not start, ensure that the proper feedback mode was selected and enabled. The system will not change the feedback type itself or enable itself to ensure that an operator is ready to have the motor enabled.

11.9 Drift

Due to the high resolution of the sensors in the windowing mode, they are susceptible to mechanical thermal drift of the sensors themselves. If the drift on the windowed sensors becomes an issue it is necessary to have better thermal control of the area where the system is being used. Expected drift values are on the order of -500ppm/degree C for both the load cell and displacement readings.

Additionally, the system is outfitted with a temperature sensor that constantly monitors the temperature of the load cell. This temperature can be used to calibrate and monitor the thermal drift of the load cell and displacement sensor, if desired.

12 Appendices

12.1 LabVIEW General Interface Notes

12.1.1 SI Units

International System of Units (SI) values are displayed and entered into numeric inputs using a case sensitive letter as abbreviation after the number:

10^{-12} = pico = p

10^{-9} = nano = n

10^{-6} = micro = u

10^{-3} = milli = m

10^{3} = kilo = k

10^{6} = mega = M

10^{9} = giga = G

For example, .00274 meters is equal to 2.74 millimeters or 2.74m

1453 Newtons is equal to 1.453 kilonewtons or 1.453k

12.1.2 XY Chart

The XY chart is how plots are displayed in LabVIEW. In some cases Psylotest will allow you to adjust the way that the plot is displayed. Adjustable plot parameters are seen in Figure 12.1.

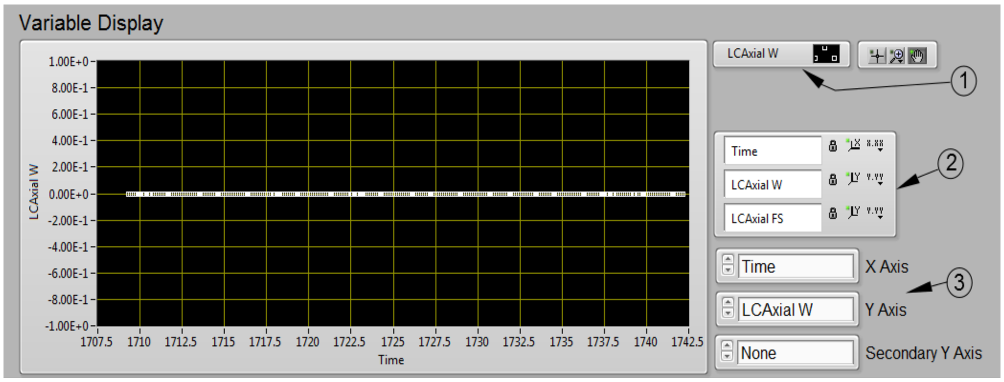


Figure 12.1 XY example 1. Data plot parameters, 2. Axis control, 3. Axis Selector

The data plot parameters (Fig 12.2) can be changed from a line plot, point plot etc. The default setting is to zoom to fit the existing data. You can change the zoom to see a section of the graph in more detail. The panning button allows you to move around the graph.

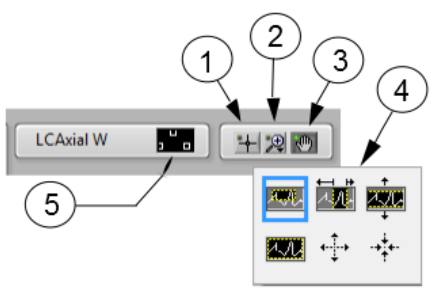


Figure 12.2 Data Plot Parameters, 1. Cursor Movement, 2. Zoom Button, 3. Panning Tool, 4. Zoom Pulldown Menu Expanded, 5. Plot Format Button

The axis lock keeps the data from scrolling beyond the range of the axis, constantly autoscaling. The manual auto-scale button sets the length of the axes based on the data currently the waveform if the axis lock is disabled. The scale format changes the format, precision and mapping of the axis. See figure 12.3 for an example.

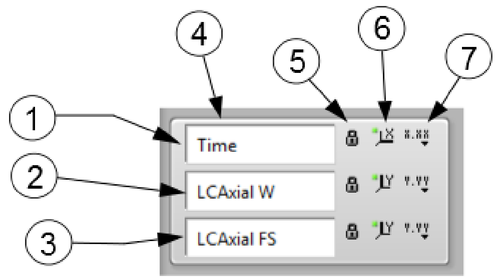


Figure 12.3: 1. X-Axis, 2. Y-Axis, 3. Secondary Y Axis, 4. Scale Label, 5. Axis Range Lock, 6. Manual Auto-scale Button, 7. Scale Format Button

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