**Tensile Tester User Manual**

**Revisions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision** | **Author** | **Changes** | **Date** |
| 001 | Tait Richards | Initial Release | <2021-08-23> |

**Table of Contents**

[1 Introduction 3](#_Toc80885099)

[2 Setup 3](#_Toc80885100)

[2.1 Raspberry Pi 3](#_Toc80885101)

[2.1.1 Boot Process 3](#_Toc80885102)

[2.1.2 Network Configuration 4](#_Toc80885103)

[2.2 Tensile Test Frame 5](#_Toc80885104)

[3 The Web-Interface 5](#_Toc80885105)

[3.1 Access 5](#_Toc80885106)

[3.2 Layout 5](#_Toc80885107)

[4 Rotational Motion 6](#_Toc80885108)

[4.1 Zeroing 6](#_Toc80885109)

[4.2 Relative Zero 7](#_Toc80885110)

[4.3 Motion 7](#_Toc80885111)

[4.4 Unwinding & Homing 8](#_Toc80885112)

[5 Tension Control 9](#_Toc80885113)

[5.1 Zeroing 9](#_Toc80885114)

[5.1.1 Zeroing & Calibrating the Load Cell 9](#_Toc80885115)

[5.2 Motion 11](#_Toc80885116)

[6 Data Logging 12](#_Toc80885117)

[6.1 Starting and Stopping 12](#_Toc80885118)

[6.2 File Retrieval 12](#_Toc80885119)

[6.2.1 VNC 12](#_Toc80885120)

# Introduction

This user manual is written to walk someone through the setup and operation of the tensile test frame.

# Setup

The setup of the Raspberry Pi 3 B (RPi) and the test frame itself for intended use.

## Raspberry Pi

### Boot Process

The RPi should be powered on first to prevent uncontrolled motion of the test frame. To power on the RPi simply plug the USB micro power cable into the RPi and the other end into the wall brick. While the RPi boots up you should see a solid red light and a flashing green light on the board. Wait until the green light stops flashing, this indicates the RPi has finished the boot process.

A picture containing text, electronics

Description automatically generated

### Network Configuration

#### Connecting to a Network

Now that the RPi has successfully powered on we need to access the web interface to control the machine. First the RPi must be connected to a network, a wired connection will be simplest, requiring only to be plugged in using an ethernet cable. However, if a wireless connection is desired It is easiest to connect a monitor, keyboard, and mouse to perform the network configuration. From here the desktop[[1]](#footnote-1) can be used to connect to a wireless network.

#### Finding the IP address

Now that the RPi is connected to a network we need to know its IP address to be able to access the web interface. The RPi should default[[2]](#footnote-2) to 192.168.0.200 as its IP address, if it is available on the network. However, if this does not work, we must find the IP another way. If a monitor, keyboard, and mouse were used in the previous step we can easily find the IP address using the “ip address” command in the terminal as shown in the picture below (ignore the “/24” at the end of the address).

Graphical user interface

Description automatically generated However, if the wired approach was taken the IP address can be found using another computer[[3]](#footnote-3) to avoid connecting any peripherals.

## Tensile Test Frame

The test frame itself is easy to setup, only requiring the 24V power supply to be plugged into the wall. You may hear the stepper motors hiss, that is normal behaviour.

**A picture containing text, indoor, table, floor

Description automatically generated**

# The Web-Interface

## Access

Here you will find the user interface for controlling the tensile test frame. The web interface can be accessed at <IP\_OF\_RPI>:1880/ui where <IP\_OF\_RPI> defaults to 192.168.0.200 but could be something different depending on network configuration.

## Graphical user interface Description automatically generatedLayout

# Rotational Motion

## Zeroing

The zeroing process is very simple, usually only requiring the press of a button. However, there are a few things to consider first. Always ensure the system is unwound before zeroing the rotation. This is because zeroing the rotation causes the system to forget how wound the cables are, so if a full revolution or two has been made, then the system is zeroed, the unwind warning will fail to warn you when the cables should be unwound. To prevent this, only zero the rotation while the cables are fully unwound, the relative zero function is inactive, and the zeroing arm is behind (counterclockwise of) the switch as shown in the image below. A close-up of a car engine

Description automatically generated with low confidenceOnce these checks have been made, simply click the “zero rotation” button. It is good practice to re-zero the system every time it is powered on, although the system will remember its last position it will not know if it is rotated while off.

Although both rotary tables have switches for zeroing only one is used. This is because the motors cannot be controlled individually. If they somehow drift out of sync, one motor can be unplugged and manually rotated to match the other. However, this is not required as the system will operate properly regardless. Furthermore, the system is prevented from zeroing when an unwind is recommended; this is to prevent accidental breakage of the cables from excessive winding.

## Relative Zero

The relative zero functionality allows the user to set the zero position to a position independent of the zeroing switch and then restore the original zero once finished with the relative zero. To use this functionality simply move the machine to your desired zero position and click the “set relative zero” button. Once you are finished with the relative zero, just click the “restore original zero” button to Graphical user interface, application

Description automatically generatedreturn to the original zero.

Note: While a relative zero is active the unwind warning will function in relation to the relative zero, for this reason do not set the relative zero more than 1 revolution away from the original zero.

## Motion

There are multiple ways to move the rotational axis a specific amount, although they are all essentially the same. These ways are listed in the below table:

|  |  |
| --- | --- |
| Name | Description |
| Change Angle | Rotates the axis by a certain number of degrees. This is best used to rotate through a specific angle. For example: if the current angle is 40° and you input 30°, the resultant angle will be 70°. |
| Set Angle | Rotates the axis to a specific angle via the shortest route. This is best used if you want to rotate the axis to a specific position. Regardless of the current angle if you input 30° the resultant angle will be 30°. Note: because this method always takes the shortest route to a specific angle it may rotate opposite to the expected direction. |
| Move Steps | Rotates the axis by a specific number of steps. This is best used for fine adjustments as each step is 1/80 of a degree. For example, if the initial angle is 30° and 10 steps is input, the resultant angle is 30.125°. |

There is also a switch to disable the stepper motors, this should only be used if all rotational motion needs to stop immediately, or if the axis needs to be rotated manually. If the steppers are disabled while in motion the system will lose track of the rotational position and the system must be re-zeroed. It is good practice to re-zero the system whenever the steppers are disabled.

## Unwinding & Homing

Graphical user interface, text, application

Description automatically generatedThere are two other ways that move the rotational axis, the first is the “unwind” button which will undo all motion since the last zeroing, unwrapping the cables from the equipment. There is an unwind warning in place which will warn the user if more than one rotation has been made since the last zero. Note: you are prevented from zeroing the rotational axis while unwinding is recommended to prevent excessive winding.

The second way is the “home” button which will return the system to 0° by the shortest route possible, this may cause the cables to wind further and thus the “unwind” button is usually preferred.

# Tension Control

## Zeroing

### Zeroing & Calibrating the Load Cell

Zeroing the load cell will set the current tension to be the zero point, this is useful for removing all the tension not passing through the sample from the measurements. The load cell is zeroed simply by clicking the “zero load cell button”. It is also important that the load cell is properly calibrated to ensure the readings are accurate. Calibration is a multi-step process:

1. First remove the load cell from the machine and place it on the table. It’s easiest to unplug the cable and screw off the load cell and re-plug the cable once it’s on the table

A picture containing disk brake

Description automatically generated

1. Wait 30+ minutes, this is done to mitigate load cell creep
2. Zero the load cell using web interface
3. Place known calibration weight on load cell

A picture containing indoor

Description automatically generated

1. Wait 30+ minutes, this is done to mitigate load cell creep
2. Input calibration weight into web interface and press “calibrate” button Graphical user interface, text, application, chat or text message

   Description automatically generated

Calibration is finished when tension values begin to appear again

1. Remove calibration weight and test calibration with different known weight
2. Re-attach load cell to tensile test frame
3. Re-zero system as required after attaching chucks and sampleA picture containing dirty, miller

   Description automatically generated

Note: There are other settings on the OpenScale that can be changed such as report rate and averaging multiple readings. This would be done by plugging the USB cable into another computer using a serial terminal to configure the settings. More details can be found here: <https://learn.sparkfun.com/tutorials/openscale-applications-and-hookup-guide/all#configuration>

## Motion

The current motion system is tension based, meaning the linear actuator is not controlled manually. Instead, a target tension is set, and the actuator will attempt to achieve that. However, there is an option for manual motion for use in loading and unloading the sample and tensioning the sample. For controlling the motion there are multiple UI elements which each perform as specific task. These are listed in the below table:

|  |  |
| --- | --- |
| Name | Description |
| Change Tension | Increments or decrements the target tension by the input value. This box will retain the previous value for easy, evenly spaced increments. If the current target value is 30 and 10 is input, the result will be 40. |
| Set Tension | Changes the current target tension to the input value. If the current target value is 30 and 10 is input, the result will be 10. |
| Actuator ON | This switch enables the linear actuator to move. If it is not activated the linear actuator will not move. |
| Manual Actuator control | This switch changes between automatic and manual actuator control, while ON the system can only be moved using the manual controls. While OFF, the system will instead attempt to reach the defined target tension. |
| Direction | This switch controls which direction the linear actuator moves while under manual control. **This switch has no effect on automatic control.** ON = Extend, OFF = Retract |
| Stepped Actuator Motion | This switch controls whether the system will move continuously under manual control, or whether discrete steps and the “Step Actuator” button will be used. **This switch has no effect on automatic control.** ON = Stepped Control |
| Step Actuator | While the “Stepped Actuator Motion” switch is on this button will cause the linear actuator to move in the direction defined by the “Direction” switch for 100ms at the speed defined by the speed slider |
| Speed Slider | This slider controls the speed at which the actuator moves **while in all modes.** The current speed is shown below the slider and is from 0-511, this is a unitless speed. Unless the system is unloaded the speed should be kept as low as possible such that the motion is more controlled and accurate, as well as being less dangerous. |

Note: The “speed” slider controls the voltage supplied to the DC motor in the linear actuator instead of its actual “speed”. Which means that a low “speed” setting also results in a lowered torque, reducing the maximum force that can be applied.

### Automatic

Automatic actuator control first starts with setting the desired tension. Then the actuator must be turned on and manual control must be turned off. The system will now try to reach the desired tension. If the system does not immediately start to move you may have to turn the actuator off and on again. However, the actuator often moves too fast, and the tension is reported too slowly resulting in large fluctuations in tension. To correct this the speed must exactly correctly, too high and the tension will oscillate, too low and the actuator will be unable to reach the desired tension. This mode should not currently be used in the experiment as it is liable to break the sample prematurely. This mode however is useful for unloading a unbroken sample if a very low target tension is set and then the actuator is turned off to prevent further oscillations. (The system will not move automatically if the target tension is zero)

### Manual

Manual actuator control comes in two different flavours, continuous and stepped.

While in continuous mode the actuator will move in the specified direction at the specified speed until either reaching the end of its travel, or until it is manually stopped. To use continuous mode the actuator must be on, manual mode must be on, the direction should be set correctly[[4]](#footnote-4), stepped actuator motion mode should be off, and the speed should be set as desired. Now the actuator should move continuously in the specified direction at the specified speed. This mode is not ideal for the tensioning of a sample as it can be challenging to stop the actuator before reaching a very high tension, though this can be remedied using a low speed

While in stepped mode the actuator will only move for 100ms following the “Step Actuator” button being pressed. To use stepped mode the actuator must be on, manual mode must be on, the direction should be set correctly4, and the speed should be set as desired. Now the actuator should move for 100ms in the specified direction at the specified speed. This is the best mode to use in the experiment as it allows the tension to be manually incremented and decremented with quite high precision. (The actual amount the tension changes by is determined by the set speed, slower = smaller steps) If the speed is set too low, the system may be unable to further increment the tension.

# Data Logging

## Starting and Stopping

The system is also configured to be able to log the position and tension of the system to a csv file multiple times per second.

To begin data logging, input the name you want the file to be saved as, next click the “start logging” button. The system will continue to record data to the file until you click the “stop data logging” button. If multiple files are created with the same name, the second file will be appended to the first.

The current format is: time, tension, rotational position (in steps)

## File Retrieval

The files are saved to /home/pi/tensile-tester/log on the RPi’s filesystem and will have to be retrieved before use. This could be done simply by removing the SD card from the RPi and plugging it into another computer. However, this is tedious and there are a couple ways to do this over the network.

### VNC

1. Download and install VNC viewer, this allows us to access the desktop of the pi remotely. Which can be found here: <https://www.realvnc.com/en/connect/download/viewer/>
2. next launch the program and you should be met with this screen: Graphical user interface, application

   Description automatically generated
3. Graphical user interface, application

   Description automatically generatedGo to file>new connection, input the connection details and click OK.   
   Note: if an IP different from the default was configured earlier use that here in place of 192.168.0.200.
4. You should have returned to the main screen where you should double click on the newly added computer. It should try to connect for a few seconds, then ask for login information.

Graphical user interface, text, application

Description automatically generated

1. A screenshot of a video game

   Description automatically generated with medium confidenceAfter logging in you should be brought to the desktop of the raspberry pi, from here right click on the VNC logo at the top right and select file transfer
2. Navigate to /home/pi/tensile-tester/log and click OK to download the whole folder, or select an individual file.
3. Graphical user interface, text, application

   Description automatically generatedA screenshot of a computer

   Description automatically generated with medium confidenceA new window should open on your own computer indicating the successful transfer
4. Graphical user interface, application, Teams

   Description automatically generatedThe new folder/file should be found on your desktop.

1. A more detailed explanation on using the desktop to connect to wireless networks: <https://www.raspberrypi.org/documentation/computers/configuration.html#using-the-desktop> [↑](#footnote-ref-1)
2. More information on configuring static IP addresses can be found here: <https://www.raspberrypi.org/documentation/computers/configuration.html#static-ip-addresses> [↑](#footnote-ref-2)
3. For more detail on finding the IP of a Raspberry Pi: <https://www.raspberrypi.org/documentation/computers/remote-access.html#how-to-find-your-ip-address> [↑](#footnote-ref-3)
4. sometimes the actuator will move in the opposite direction than specified, in this case just flip the direction switch ON and then OFF which should correct the issue. [↑](#footnote-ref-4)