<P15662: Reciprocating Friction Tester>

Operations & Maintenance Manual

Version *<1.01>*
Date *<05/11/2015>*

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1 Introduction

1.1 Purpose

The goal of this project is to design a reciprocating friction tester composed of the armature and base subsystem. This subsystem has the purpose of providing a constant and accurate vertical normal force through a single point of contact. This normal force must be variable up to 20N with a 0N load release, aka resting force. This means the weight of the armature must not effect or add to desired normal force. The subsystem must be able to measure, store and display the friction force and the normal force that is being applied to the plate specimen during testing.The armature must be fully functional and securely attach to the reciprocating system which is being designed and developed in parallel. The friction tester must conform to multiple ASTM standards, ASTM-G-133-05, ASTM G-181, ASTM – D-5706-05, and ASTM-D-5707-05.

1.2 Audience

This document is meant for Dr. Patricia Iglesias-Victoria and anyone she has authorized to use the Reciprocating Friction Tester

2 System Description

2.1 Key requirements/Components

The key features of the system are listed below and are met in the design. The components are also spelled out

Requirements:

System must not exceed 4' x 6'
Motor able to supply torque necessary for 20N applied normal load
Base does not deform under a minimum of 20N applied normal load
Device will withstand a 24 hour test duration
Data acquisition system integrates with labview
Interface armature system from P15660 team
Base accepts variable sized specimens
Device will accommodate for both dry and lubricated specimen tests
Heats specimen to 200*C
Variable stroke 2-10mm
Variable frequency 1-10 Hz
User/repair manual included
Easy to clean oil off base
All data in SI units
Labview program works for both rotating and oscillating test rigs
Test rig must remain stationary during operation
System is safe to be around when running.

Components:

Armature subsystem:

- Rear aluminum block
- Front aluminium block
- Armature subsystem: Mounting block, linear shafts, lead screw
- Sensor subsystem: Strain gauges and Labview

Reciprocating subsystem:
- Specimen holder
- Linear guide
- Voice coil
- Encoder
- Motion controller

2.2 Environment

With regards to the conditions for operation of the friction tester, standard room temperature would be ideal for optimum performance.

2.3 System Safety and precautions

Enter the purpose of these precautions here

2.3.1 Strain Gauges

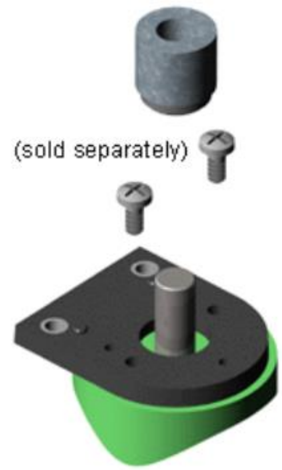
The wires of the strain gages are extremely fragile and care must be taken whenever moving or dismantling the system. It is important that there is always a little extra slack in the wiring to allow movement without putting taught pressure on the gage wires. The taping of the gages or wiring interface should not be interfered with unless needed to remove the wiring or gage from the system. When moving the system or dismantling the arm, do not set the arm in such a way that the gages are making direct contact with the table or whatever you set it on.

2.3.2 Encoder

Always read through ENC-A2 Series Assembly Instructions Guide before handling the encoder. It is imperative to know how the assembly goes together before handling this device. ENC-A2

ENC-A2 Series Assembly Instructions Guide

Step 1: Base Mounting
Slip the base and centering tool (sold separately) over the shaft. Adjust the base to align the base holes with



the screw holes on the mounting surface. Press down on the centering tool to secure it to the mounting surface. Fasten the mounting screws to the mounting surface and remove the centering tool.

Step 2: Spacer Tool Installation
For shafts less than 3/8”, snap the space tool clip around shaft (Figure A). For shafts equal to or greater than 3/8”, place spacer tool around the shaft (Figure B).

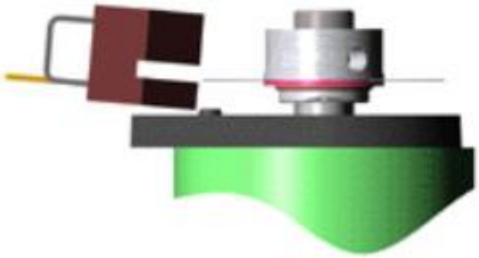
Figure B. Space Tool

Figure A. Spacer Clip

Step 3: Codewheel Installation
Slip the codewheel over the shaft with the disk side down until it touches the space tool. Tighten the set screw with the provided hex wrench while pressing down on the hub of the disk. Remove the spacer tool.

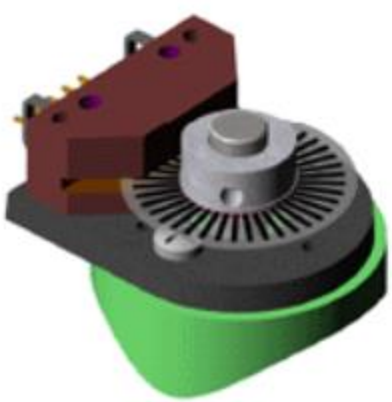
Step 4: Encoder Module Installation
Slip the optical encoder module into position until the

assignment pins slip into the holes of the module. The pins should be on the bottom of the module facing out.



Step 5: Cover Installation

Place the cover over the assembly and secure the components in place with two 4-40 x 5/8” screws supplied with the kit.



When fastening the encoder base, leave the screws loose until the centering tool is pressed into place. Tighten the screws to secure the base relative to the centering tool.

The Allen key sized to the codewheel set screw can be used in absence of the spacer clip.

Most importantly, handle the codewheel with the utmost care. Do not touch the clear plastic portion, else skin oils will contaminate the reading surface. Do not handle, squeeze, or use tools on the plastic portion of the codewheel, or it may warp. Always handle the codewheel by the aluminum hub disk. Work slowly and consider using small tweezers or needle pliers to hold the hub disk. Once the hub disk is supported on the support shaft, it can be pushed into place by the aluminum hub. The centering tool can also be used to push the codewheel into place safely.

When positioning the brown encoder module into place, it should be given a slight angle so as to clear the codewheel. The encoder module should sit into divots formed into the encoder base. When the module is in place, verify that the code wheel is centered relative to the crevice in the encoder module. The encoder module will be held in place with the two Phillips head screws that also hold the cover on. These should be snug but do not overtighten or damage to the encoder module may occur

3 Product Installation

3.1 First-Time Users

For first time users, it is important to understand that the machine is quite sensitive so should be handled with care especially when dealing with the sensors and also it works based on a Labview program which is used for the strain-friction measurement thus proficiency in Labview is a strong requirement in order to operate the tester effectively.

3.2 Access Controls

Regular administrative privileges would be required in order to use the computer connected to the friction tester so as to gain access to Labview.

3.3 Starting the System

In order to start the system, it is important to make sure the machine is intact. Confirm proper connection of the gauge to the DAQ card then to the computer. Turn on the encoder, After this, add force weights to top of pin rod then start labview program on the computer in use. Select the required DAQ assist, input the parameters for labview then press start.

3.4 Stopping the System

In order to stop the system, hit stop on the labview program and this bring the system to a complete halt.

3.5 Suspending the System

In order to suspend the system, hit pause on the labview program and this brings the system to a halt

4 System Usage

4.1 High Level Instructions

The items below represent an overview of the steps required to operate the system

* Notes items that may not be required every setup

- Setup the armature x direction.
- Setup armature y direction
- Setup specimen in specimen holder
- Adjust height of pin to be flat
- Adjust counterbalance to ensure no force is on pin
- Apply lubricant to to specimen in use
- Place specimen into specimen holder
- Add force weights to top of pin rod
- *Attach strain gauge wires to the DAQ
- Start LabView on the computer
- Select DAQ Assist
- *Run calibration procedure
- Select stroke length (1-10mm)
- Select frequency (1-10 hz)
- Select Time for the test to run, then press start

4.1.1 Setup the armature x direction.

In order to set-up the armature in the x-direction, start by unlocking the lock, lift lock lever(show pic of lock). Depending on which direction you intend to use, turn the clockwise depending on which direction you intend or counterclockwise(direction) keeping in mind that the maximum adjustability is 27mm.. After adjusting the armature in the desired direction, be sure to lower the lock lever so that the system is in place.

pic of what the x direction is

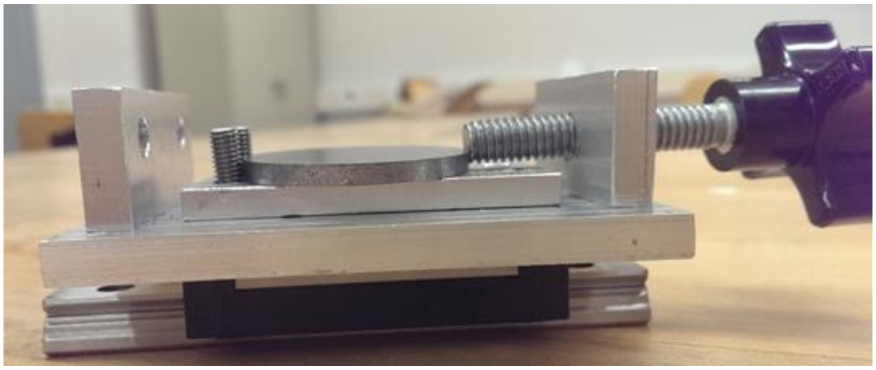
4.1.2 Setup armature y direction

In order to set-up the armature in the y-direction, simply obtain an M4 torque wrench, loosen the setscrew on the top of the counterbalance block. Adjust in the y-direction keeping in mind the maximum adjustability is 49mm. After you decided how far you want to move, retighten the set screw so that the system is in place.

pic of what y direction is

4.1.3 Setup specimen

In order to set-up the specimen holder, note that if the specimen is under 10mm, be sure to put the spacer onto the specimen holder. Next, place the specimen onto the holder then apply pressure to specimen, tighten down the knob making sure the specimen does not rise off the specimen holder.



4.1.4 Adjust height of pin

In order to adjust the height off pin, loosen setscrews on the side using an M4 torque wrench. Next, lower the specimen so that the whole system is level then tighten down the setscrews on the side.

pic of pin holder

4.1.5 Adjust counterbalance

In order to adjust the counterbalance, turn the threaded mass till the arm is stable. This ensures that the force exerted without any weight is zero.

4.1.6 Add force weights to top of pin rod

Add force weights based on desirability by simply sliding the weights on the top of the pin rod.

Weight (N)	Weights required
0.25	**1x(0.25)**
0.5	**1x(0.5)**
0.75	**1x(0.5) 1x(0.25)**
1.0	**1x(1.0)**
2.0	**1x(2.0)**
3.0	**1x(2.0) 1x(1.0)**
4.0	**2x(2.0)**
5.0	**1x(5.0)**
9	**1x(5.0) 2x(2.0)**
10	**1x(10.0)**
19	**1x(10.0) 1x(5.0) 2x(2.0)**
20	**1x(10.0) 1x(5.0) 2x(2.0) 1x(1.0)**

pic of force weights w/ weight chart

4.1.7 Setup LabView

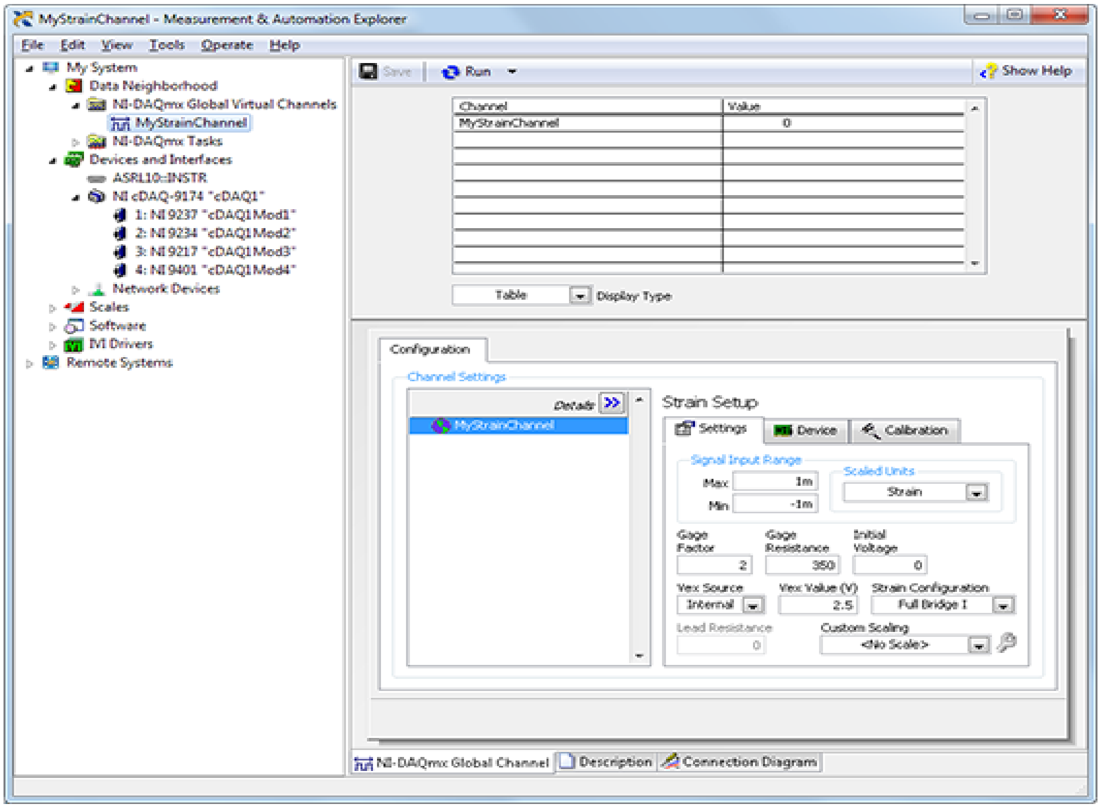
First, make sure labview is installed on the desired computer. A labview program has to be in place for the strain measurements to take place. Thus, before connecting any signals, locate your device pinout using these steps:

1.) Open measurement and automation explorer (MAX) and expand devices and interfaces.
2.) Right click on device name and select device pinouts

Next, configure a strain measurement following these steps:

3.) With MAX open, select Data Neighborhood and click Create New.
4.) Select NI-DAQmx Global Virtual Channel and click Next.
5.) Select Acquire Signals » Analog Input » Strain

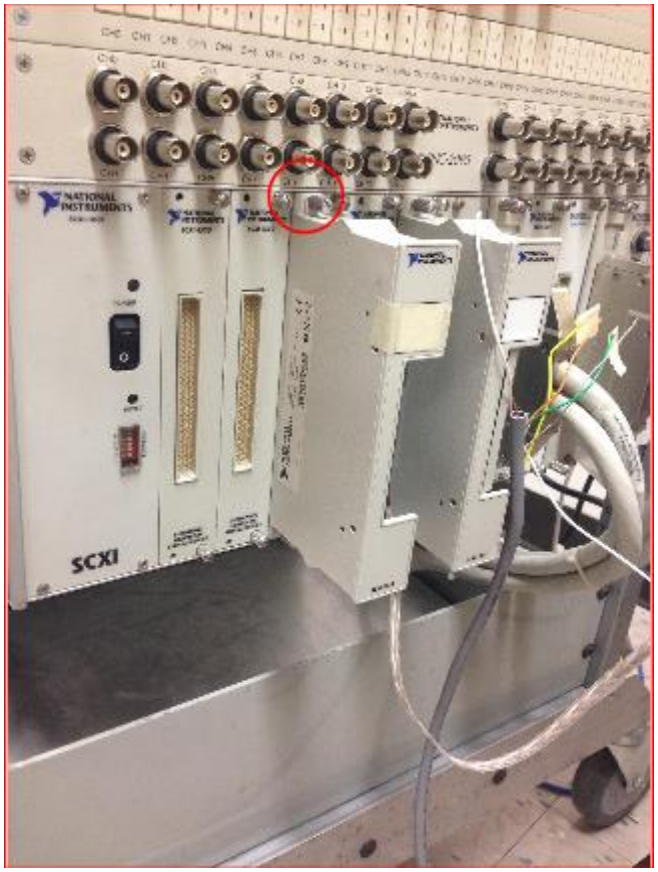
After the above steps, select the physical channels which you intend to use to connect your strain gauge to your DAQ. In this case, 4 gauges are being used thus 4 channels (a4-a7) will be selected. Click next then enter a name for the global virtual channel. Click finish and then you should see the following screen in MAX:



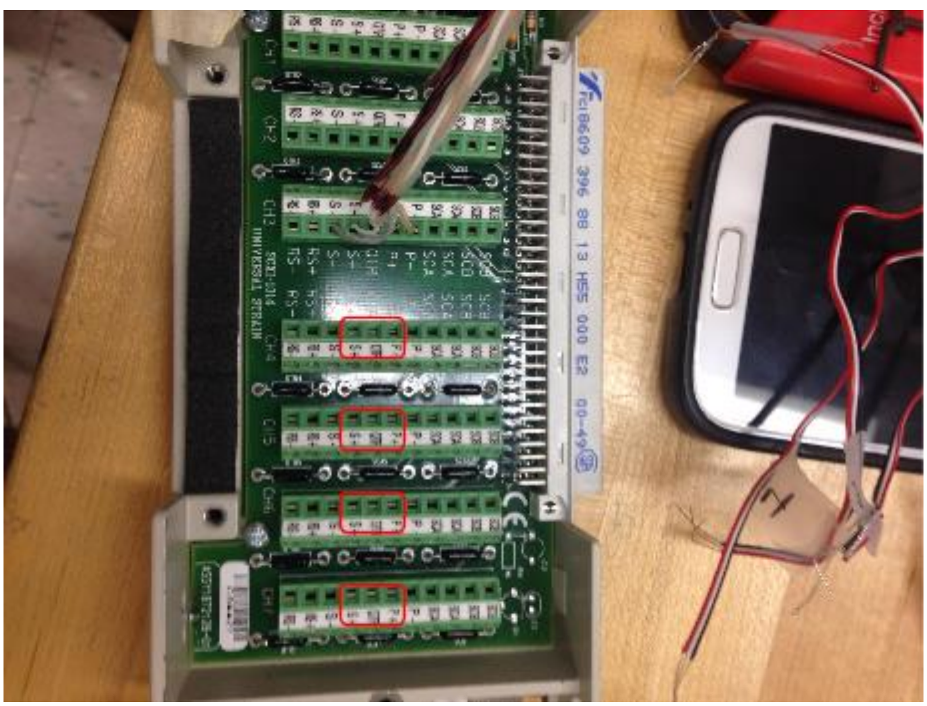
On the settings tab, input the minimum and maximum strain values as expected. Configure the Gage Factor, Gage Resistance, Initial Voltage, V_{EX} Source, V_{EX} Value (V), Lead Resistance, and Strain Configuration based on the sensor specifications. Thus, start the software, input the required stroke (1mm-10mm), time and frequency (1-10 hz). Counterbalance the arm and press start test.

4.1.8 Attach strain gauge wires to the DAQ

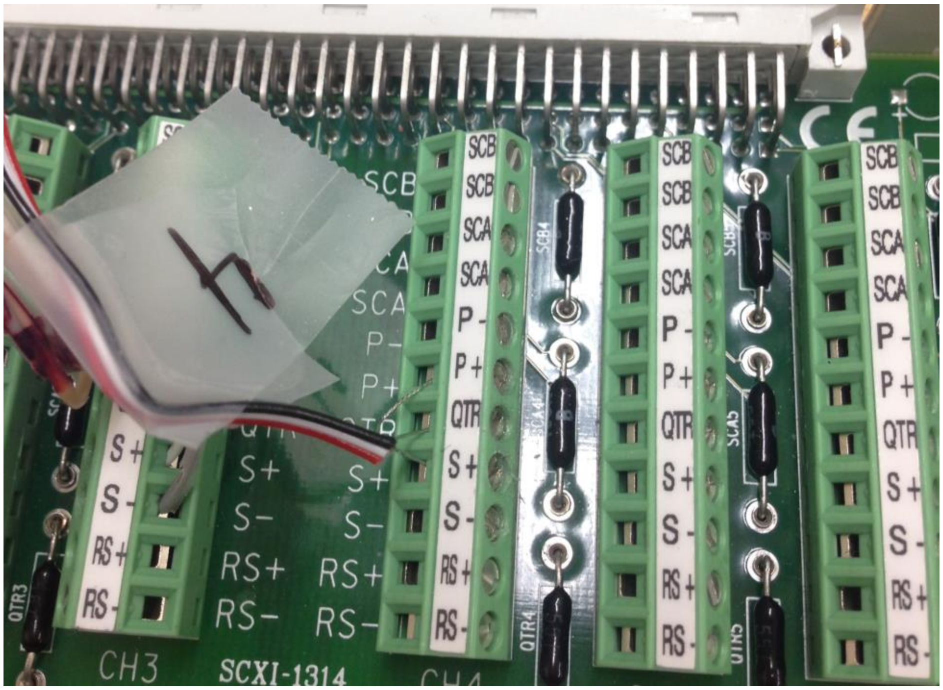
Remove the SCXI-1314 card from the SCXI-1520 data acquisition module, located underneath the computer monitor, there are screws that fasten the card in place which should be loosened, as seen in the red circle. It is the 3rd port of the SCXI-1520 and can be seen below. (the one with the tape)



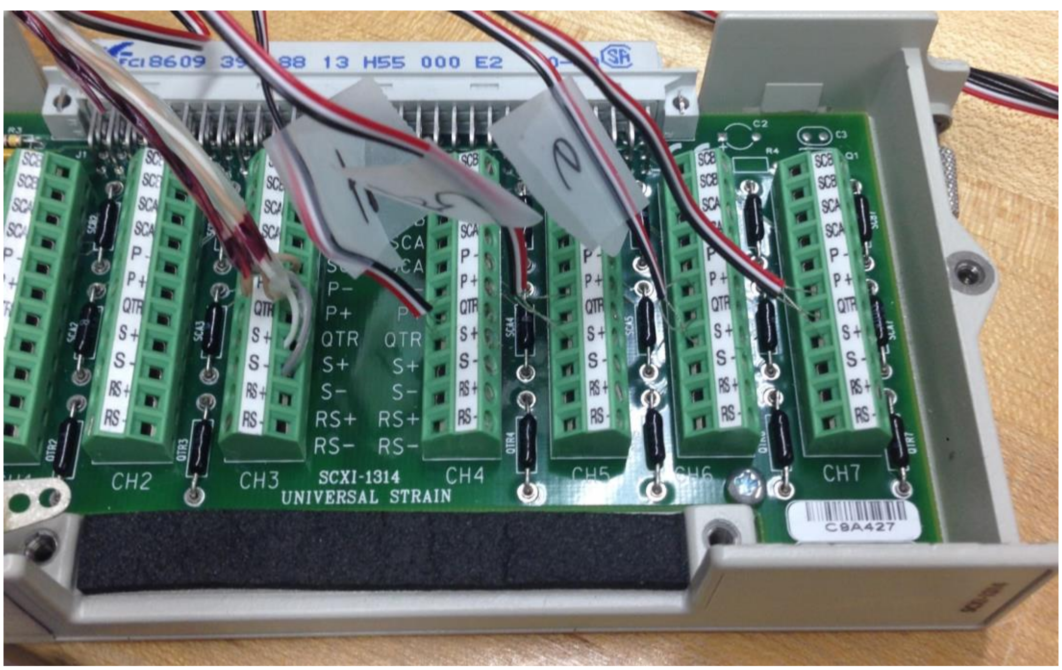
Loosen the screws of the P+, QTR, and S+ ports of channels 4, 5, 6, and 7 on the SCXI 1314 card.



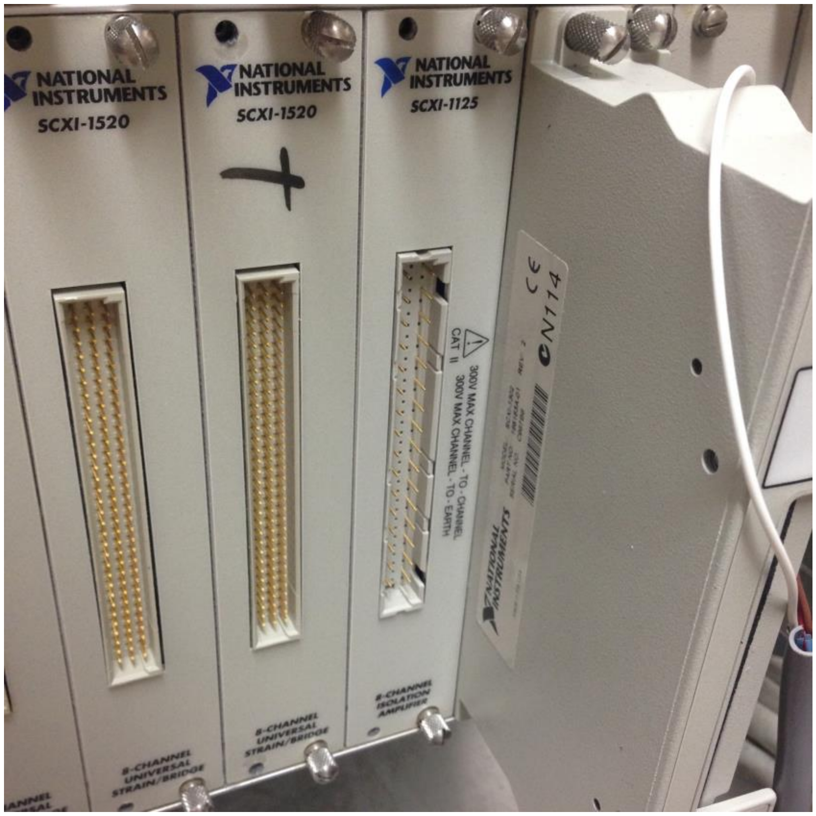
Connect the red wire of the gage leadwire labeled “4” to the P+ port of channel 4. Continue to connect the white wire to the S+ port and the black wire to the QTR port.



Repeat for each gage in their respective, labeled, channel.



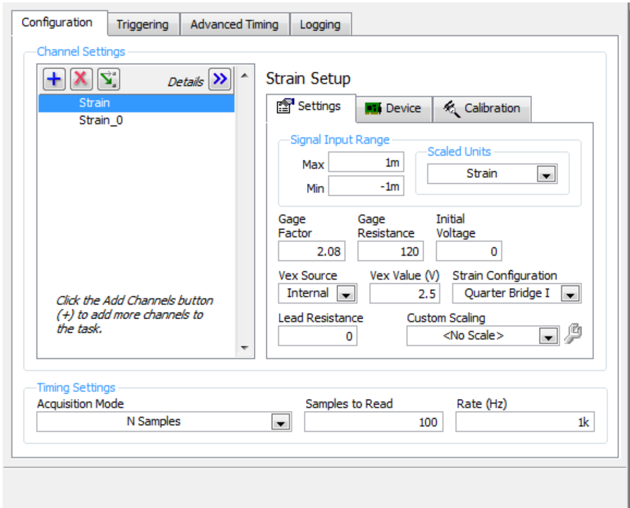
Reconnect the SCXI-1314 card to the SCXI-1520 module 3. There is a sharpied “X” on the correct port.



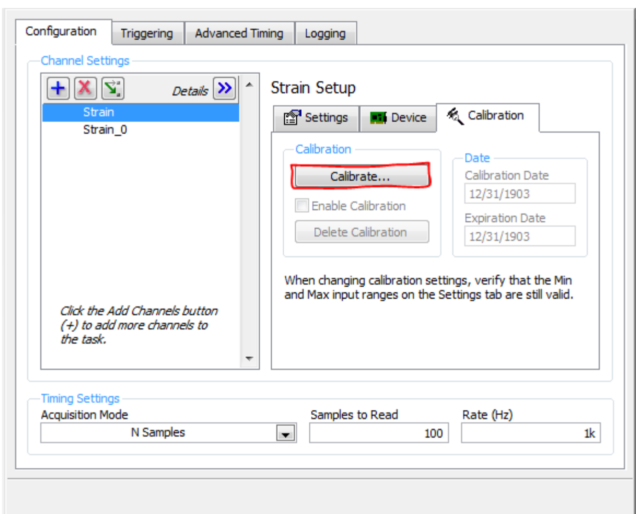
4.1.9 Run calibration procedure

You may want two people to do this to make it faster. In order to calibrate the strain gauges,get to the grid version of LabView by pressing Ctrl + E. Navigate until you find the blue DAQ Assist box and double click it.

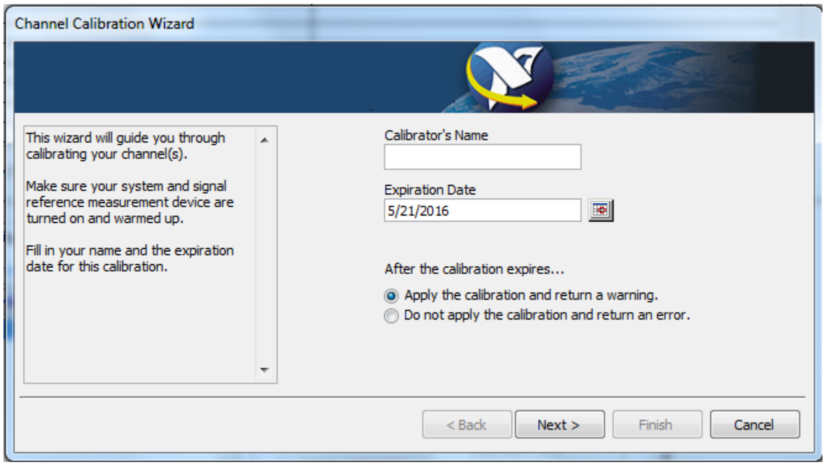
A new window will appear. Before calibrating, the settings should be as follows:



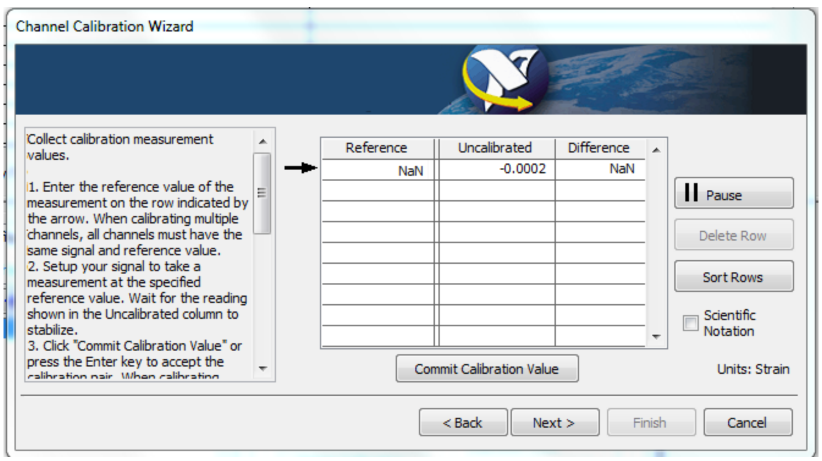
Once on this page, Select the first gauge then press the ‘Calibration’ tab, then press “Calibrate…”



Another window will appear. Type in your name and set the expiry date of the calibration to the beginning of the next semester.



When you reach the following window, it is time to calibrate the gauges.



Commit the 0 value before starting. Place the system on the corner of the table so that the perpendicular line to the pin is off of the table so both locations for calibration will be able to hang freely. First setup the stand. This requires tightening two blocks onto the edge of the base plate using a 3/16 torque wrench. Place the rod atop the two blocks. Attach the hook system to the bottom of the pin by loosening the set screw with a 5/64 torque wrench then retightening it down so it cannot slip off. Next hang the hook by itself over the edge of the stand rod. Spin the rod away from you to release any tension between the string and the rod. Since the hook is dangling, do not allow it to spin around keeping it confined to a small spin radius. Go back to the computer and write down the value you see. While looking at the computer, pull on the armature to determine which way the strain is going. If the strain goes down, you will enter negative values for this side if it goes up you will enter positive values. Use Table 1 located in Appendix B or the SGCal.xlsx file which can be found in the software folder of the P15662 edge page to determine the strain constant that corresponds to the weight of the hook. Commit the value. Next add incremental weights to the hook by pressing the bottom hook together then slipping it through the center hole of the weight then reopening the hook arms. Use the strain equation to determine the strain. Be sure to correctly enter the negative sign if necessary. Commit the value. Do this for 0.245N, 0.5N, 1N, 2N, 3N, 5N, 7N, 10N, 12N, 15N, 20N at the minimum for each side. Repeat this process from everything after committing the 0 value for the other side of the same strain gauge. Note the values will be the opposite sign of what they were for the first time.

Select the second strain gauge and repeat the process. In order to be certain, do the pull check to verify the negative sign again however this is not necessary as the values will be opposite of the first gauge. (If you went over the voice coil and it was negative for the first gauge, going over the voice coil will be positive for the second gauge).

The calibration results and data are illustrated below:

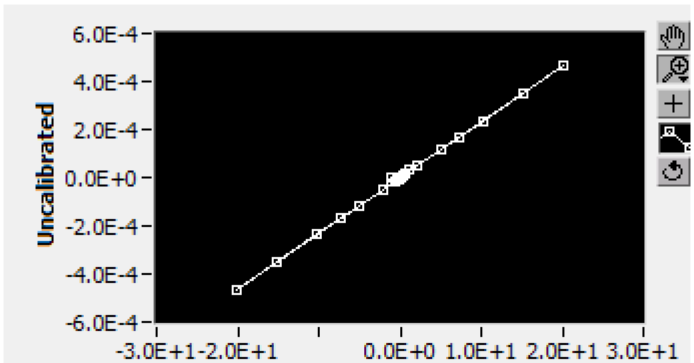


Figure 3: Calibration Plot

Reference	Uncalibrated	Difference
1.8338E-1	-6.3796E-6	1.8339E-1
4.2838E-1	8.5910E-6	4.2838E-1
6.8338E-1	1.5569E-5	6.8337E-1
1.1834E+0	2.9821E-5	1.1834E+0
2.1834E+0	4.8486E-5	2.1833E+0
5.1834E+0	1.1566E-4	5.1833E+0
7.1834E+0	1.6312E-4	7.1832E+0
1.01834E+1	2.3252E-4	1.01831E+1
1.51834E+1	3.4752E-4	1.51830E+1

Figure 4: Strain results

5 Machine Maintenance

In order to properly manage the machine, cleaning, greasing and adjustments should be performed in addition to an inspection of the bearings ability to run and of possible wear. Further, the tester should be calibrated regularly and tested for functionality to ensure it is fit for future tasks.

Specifically for the encoder and voice coil, the below steps should be noted with regards to handling and upkeep

Encoder handling instructions:

Always read through ENC-A2 Series Assembly Instructions Guide before handling the encoder. It is imperative to know how the assembly goes together before handling this device.

Link:https://www.anaheimautomation.com/manuals/encoder/L010742%20-%20ENC-A2%20Series%20Assembly%20Instructions.pdf

Assembly tips:

- When fastening the encoder base, leave the screws loose until the centering tool is pressed into place. Tighten the screws to secure the base relative to the centering tool.

- The Allen key sized to the codewheel set screw can be used in absence of the spacer clip.

- Most importantly, handle the codewheel with the utmost care. Do not touch the clear plastic portion, else skin oils will contaminate the reading surface. Do not handle, squeeze, or use tools on the plastic portion of the codewheel, or it may warp. Always handle the codewheel by the aluminum hub disk. Work slowly and consider using small tweezers or needle pliers to hold the hub disk. Once the hub disk is supported on the support shaft, it can be pushed into place by the aluminum hub. The centering tool can also be used to push the codewheel into place safely.

- When positioning the brown encoder module into place, it should be given a slight angle so as to clear the codewheel. The encoder module should sit into divots formed into the encoder base. When the module is in place, verify that the code wheel is centered relative to the crevice in the encoder module. The encoder module will be held in place with the two Phillips head screws that also hold the cover on. These should be snug but do not overtighten or damage to the encoder module may occur.

In addition, if the motion controller is unable to send commands to the correct COM port, show debug and select the correct COM port to fix it.

If the voice coil continues to run into the base reduce the starting location by showing the debug and increasing the control, this being said if it comes off the rail reduce this number.

There are also stroke and frequency constants that can be changed if the proper stroke and frequency is not being met.

6 Key Contacts

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7 Roles and Responsibilities

Chris Karmanos	Industrial Engineer
Emeka Okoye	Electrical Engineer
Reba Conway	Mechanical Engineer
Eric Kutil	Mechanical Engineer
Kolby Irving	Electrical Engineer
Alexandra Woodward	Industrial Engineer
Matt Lebowitz	Electrical Engineer
Tyler Nigolian	Electrical Engineer
Ethan Hanson	Mechanical Engineer
Sean Cummings	Electrical Engineer

8 Regulatory Requirements

This friction tester conforms to the specifications of multiple ASTM standards such as ASTM-G-133-05, ASTM G-181, ASTM-D-5706-05, and ASTM-D-5707-05.

APPENDIX A: KEY TERMS

Centering tool – small aluminum hub with one conical end. Used to ensure the encoder is centered upon the rotating shaft

Codewheel – Clear plastic disc mounted to a metal hub. This is the most delicate part of the encoder.

Encoder support shaft – Stainless steel rotating shaft supported by two bearings. The encoder has a “floating” hub that mounts to this shaft.

Encoder base – plastic plate with preformed ears and nut-serts. The positioning of the base is essential to ensuring accurate readings from the encoder wheel

Encoder Module – this unit contains all of the electronics of the encoder.

Spacer clip – Small metal clip used to determine spacing between floating hub disk and encoder base (can be substituted for appropriate allen key sized to hub set screw)

APPENDIX B: KEY TABLES

Table 1: Strain Input Table

	g	n	strain
		0	0.0000E+00
g	18.7	**0.183384356**	5.2856E-06
3.3	22	0.215746301	6.2184E-06
5.1	23.8	0.233398271	6.7272E-06
5.3	24	0.235359601	6.7837E-06
8.8	27.5	0.269682876	7.7730E-06
17.2	35.9	0.352058736	1.0147E-05
N		n	strain
0.245		0.428384356	1.2347E-05
0.5		0.683384356	1.9697E-05
1		1.183384356	3.4108E-05
1.98		2.163384356	6.2355E-05
2		2.183384356	6.2931E-05
5		5.183384356	1.4940E-04
7		7.183384356	2.0704E-04
10		10.18338436	2.9351E-04
12		12.18338436	3.5116E-04
15		15.18338436	4.3763E-04
19.98		20.16338436	5.8116E-04
This column corresponds to the weight being placed onto the hook		This column is the weight added plus the weight of the hook	ENTER THIS VALUE INTO THE CALIBRATION SHEET