Department of
NUCLEAR ENGINEERING
University of California, Berkeley
Thermal Hydraulics Laboratory

XPREX Facility Description and Users Manual

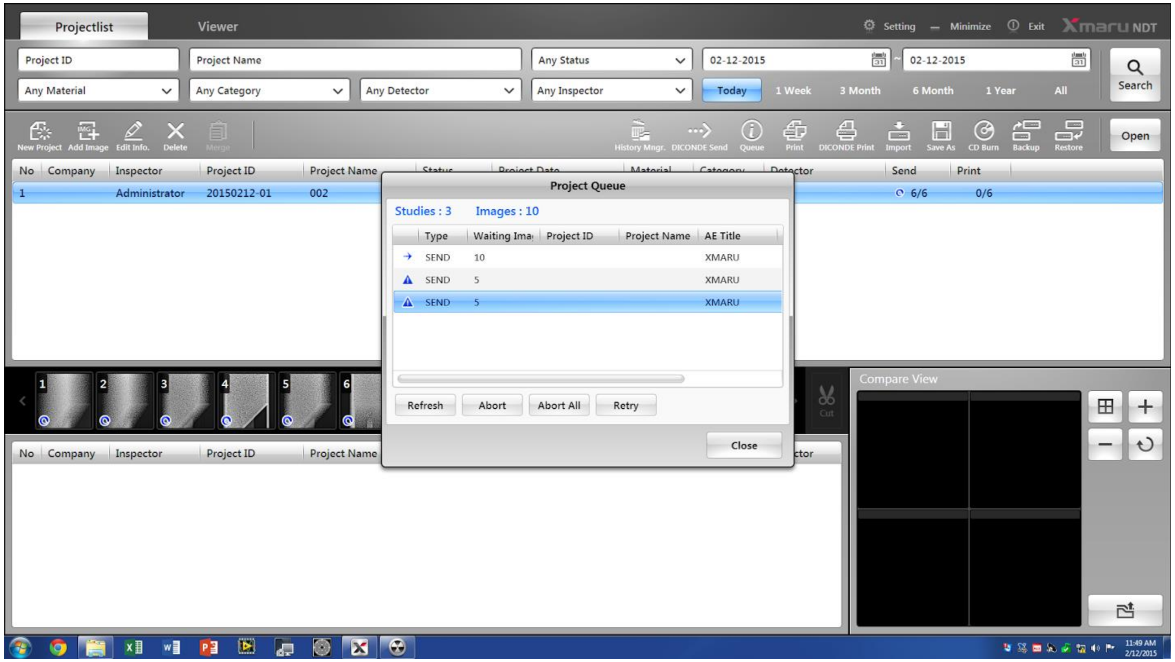
July 15, 2015

Outline

- X-Ray Acquisition and Controls
- LabVIEW Control VI
- DAQ Devices
- Automation
  - Turntable
  - Paintball Hopper
  - Linear Actuator
- Installation Procedures

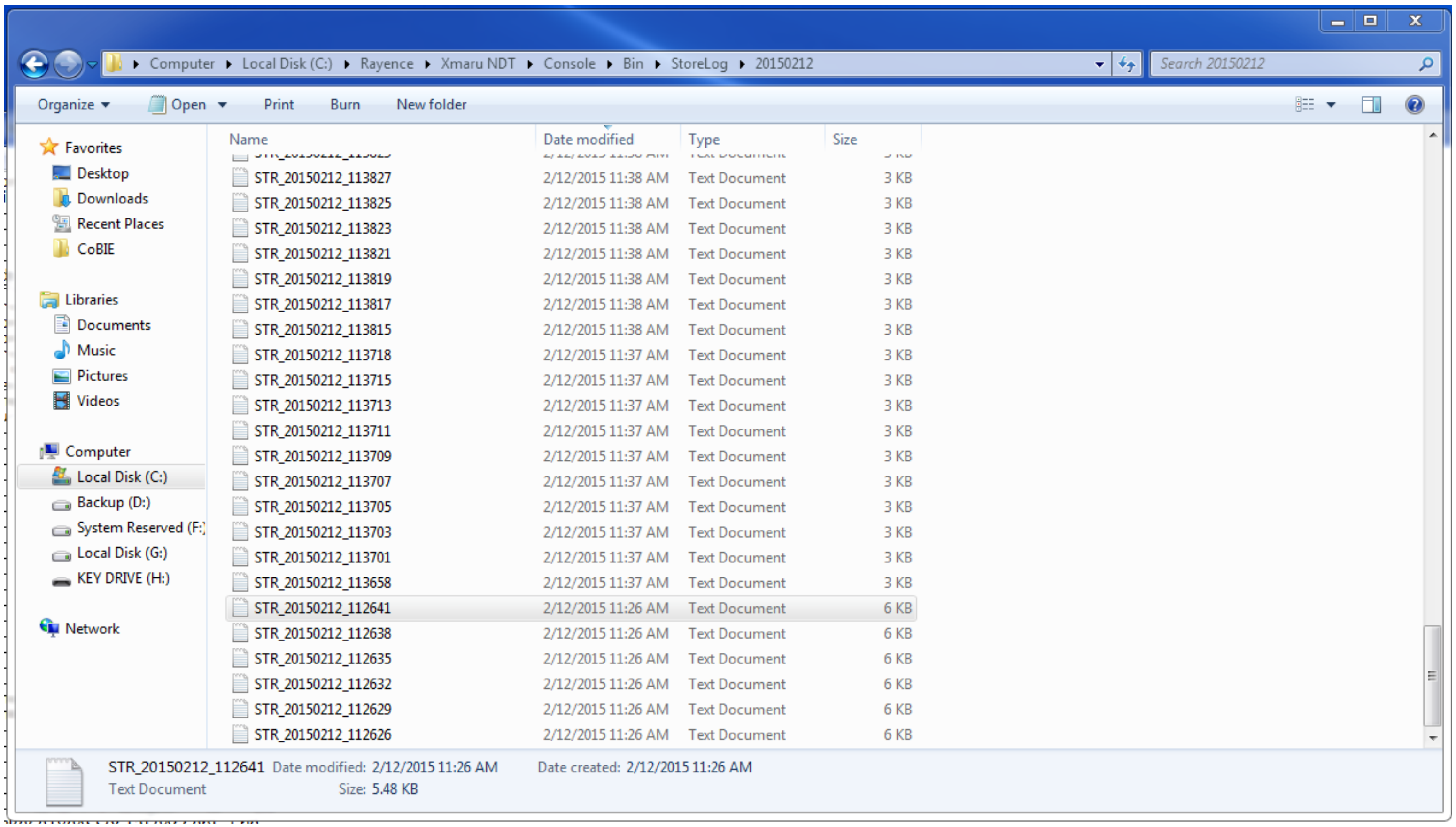
Xmaru Software

- Computer PW: rayenceusa
- Xmaru PW: 1234
- This software is very straightforward
- Main bug that you need to be cautious of:
  - In the past, after closing a study, the software has had a problem "dicom sending" the images. The study gets stuck in queue:



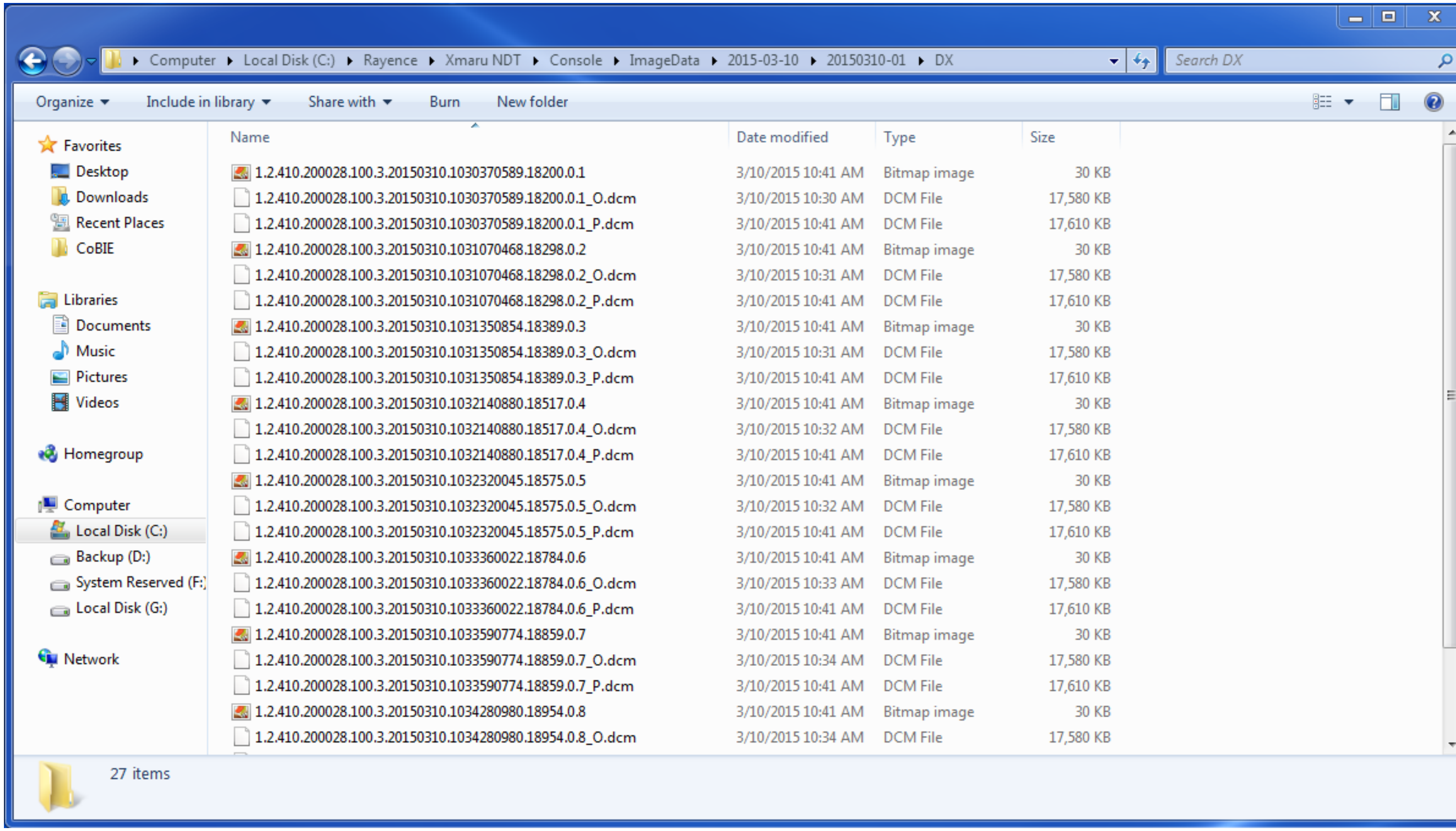
Xmaru Software

- **If this error occurs you can find the log of what the software did in the following folder:**



Xmaru Software

- **If the software errors out while sending the dicom images, you can still find the originals in the following database folder:**

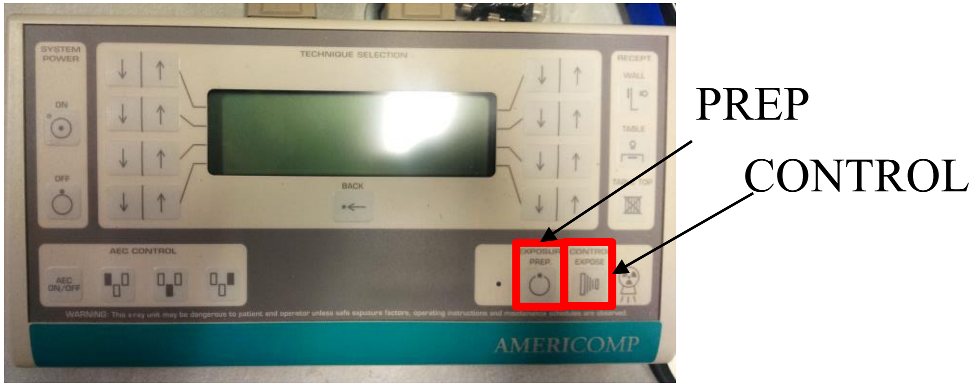


Xmaru Software

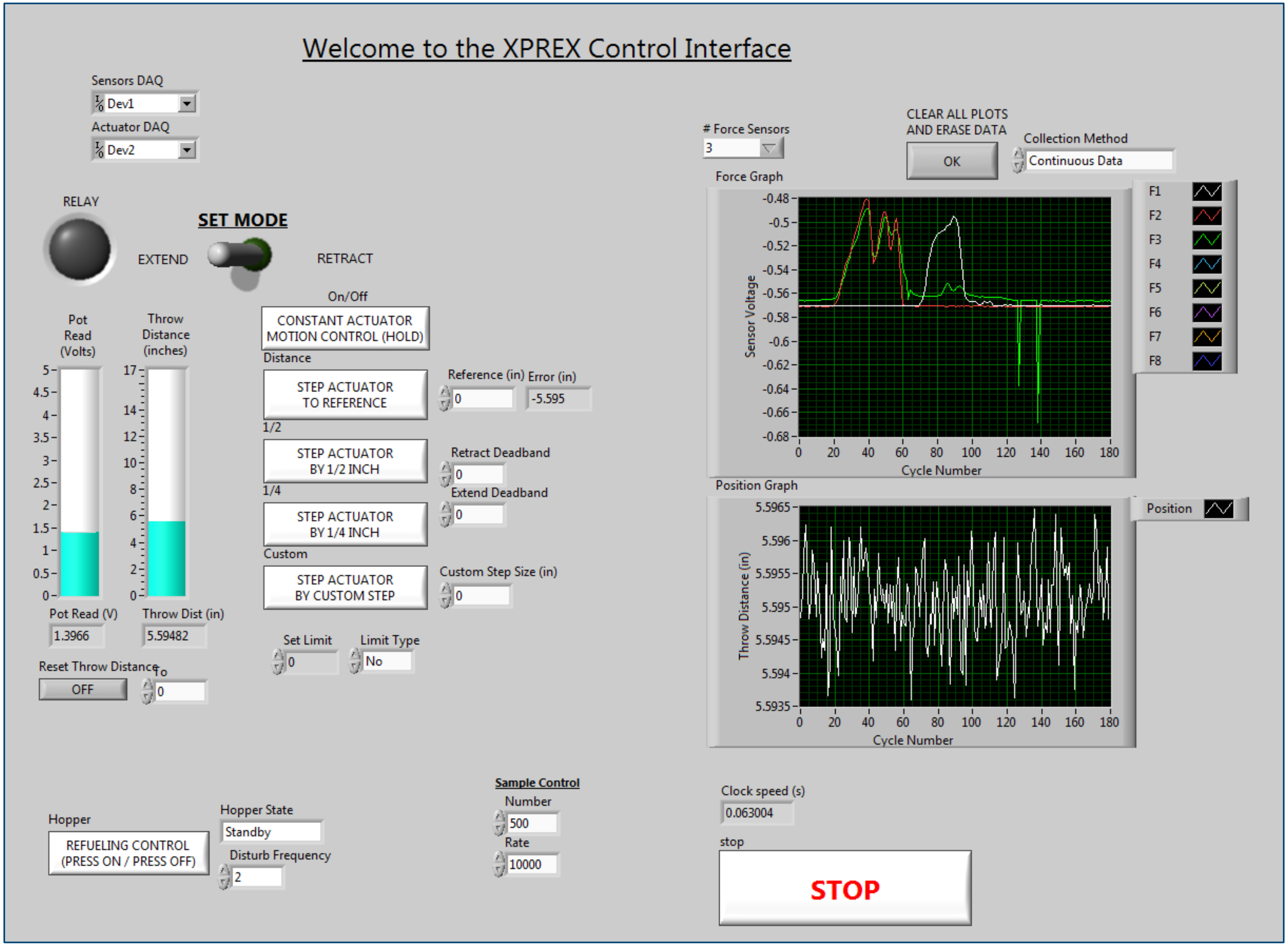
- If you get a dicom send error and try to recover the original images, you may have problems with exposure and Xmaru's image processing. Therefore, it is always better to avoid the error and export using Xmaru's integrated features.
- The main way to avoid the error has been the following:
  - Open your study, take your first x-ray
  - Close the study
    - » You should see the image processing being applied to your image and also the progress of the dicom send
  - The study should appear in the list of today's studies
    - » If it does, you're in good shape and we've never had errors in the study after that
    - » If it doesn't, you've lost one image, no big deal, restart the software and try again
- The bug is only disastrous when you have completed 100 images, close the study, and all of them cannot dicom send
- <u>Closing and reopening the study very early has always avoided this bug.</u>

X-Ray Exposure Control

- Below is an image of the x-ray controller
- You should primarily learn about this in the RUA training
- There is only one kink to the operation of this device that you should be aware of:
  - If the detector doesn't receive full exposure, the image may have brightness/contrast inconsistencies (pretty obvious when you see it)
  - To avoid this: you must continue to hold down the PREP button a moment after the "ready" beeping noise, then hold down the CONTROL and PREP button together, continuing to hold for a moment even after you hear the exposure noise.
  - This sounds like an superfluous guide but trust me, it takes a little finesse to get a proper exposure every time



LabVIEW Control VI

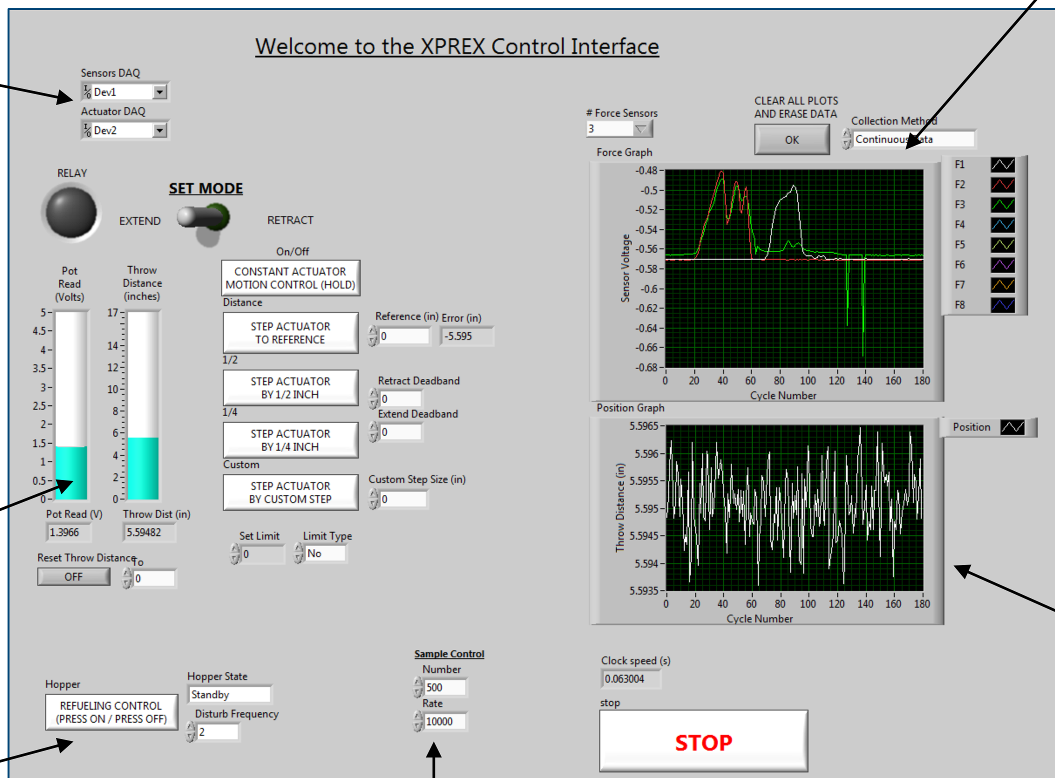


LabVIEW Control VI

- **This is the base LabVIEW VI. It has one example of everything you should need.**

Sensor data collection

Set DAQ Devices



Actuator Control

Actuator Position

Paintball Hopper Control

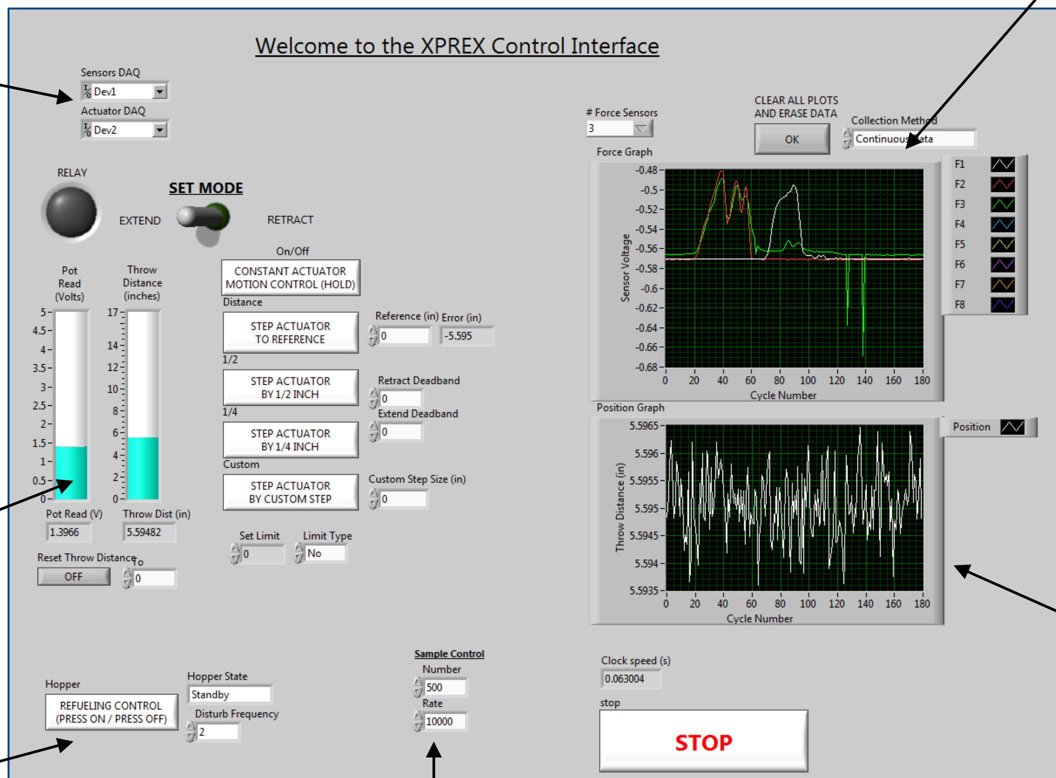
Sensor Sampling Control

LabVIEW Control VI

- **We'll go into the actuation controls separately later.**

Sensor data collection

Set DAQ Devices



Actuator Control

Actuator Position

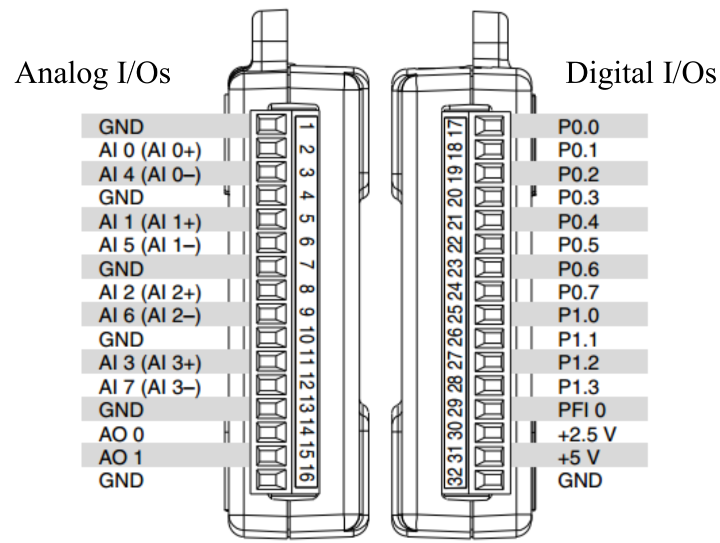
Paintball Hopper Control

Sensor Sampling Control

DAQ-6009

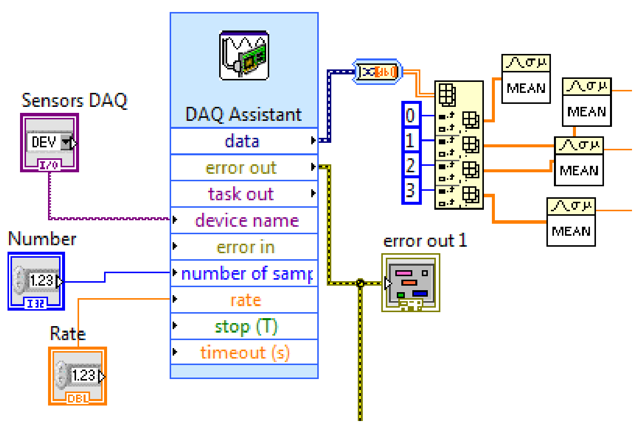
- **For all custom sensors and actuators, we use two National Instruments DAQ-6009 devices**
- **http://www.ni.com/pdf/manuals/375296a.pdf**

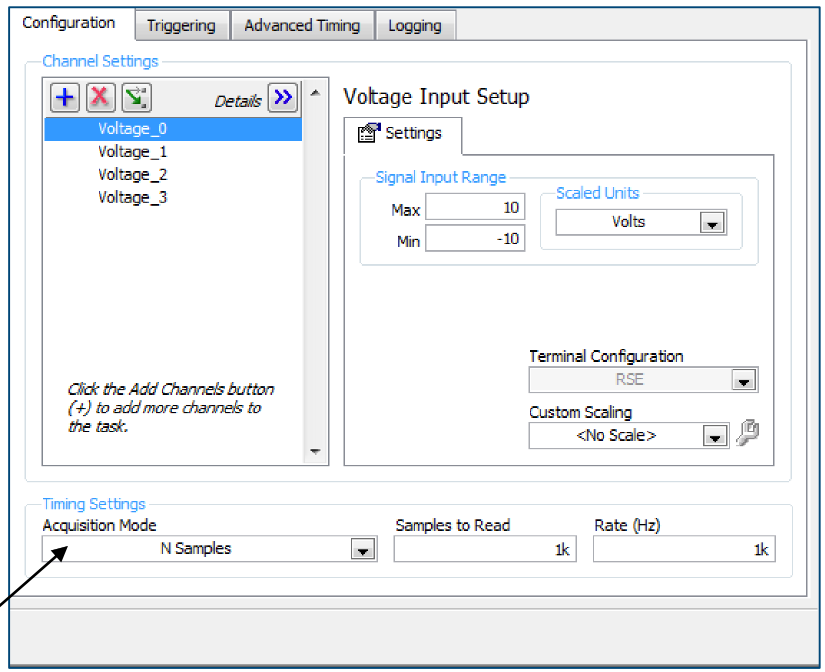
Figure 2. NI USB-6009 Pinout



DAQ-6009

- You connect to the DAQs using a standard printer (type B) usb cable
  - DAQ -> printer usb type B -> usb hub -> XL type B cable -> computer
- Use the LabVIEW DAQ assistant express block to connect the LabVIEW VI to the DAQ.
  - Sensor DAQ assistant:



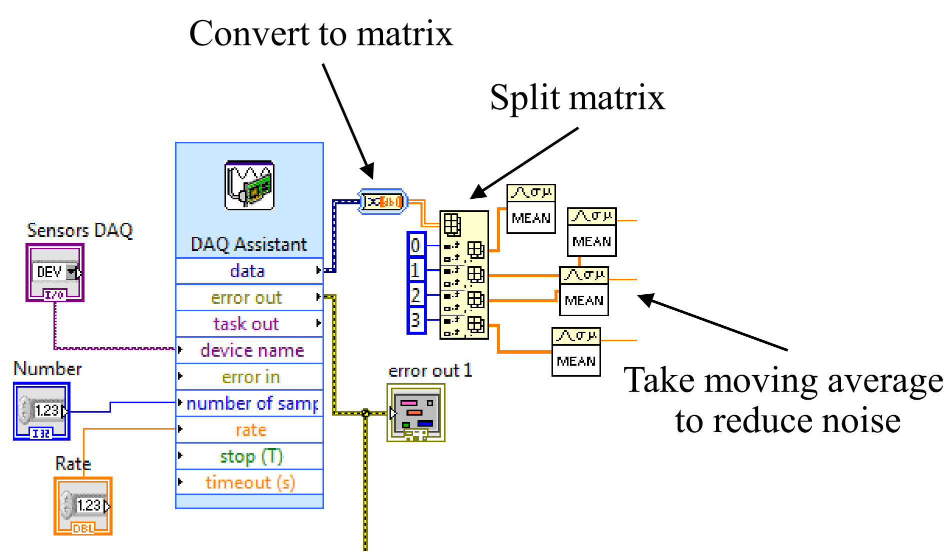


(double click on block to see this window)

This is important. Use "N Samples" or "continuous"

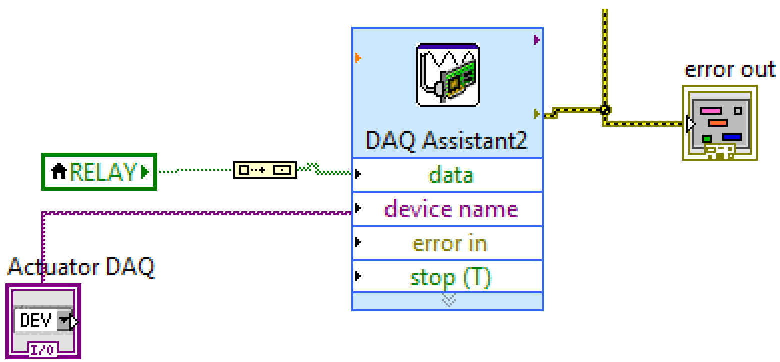
DAQ-6009

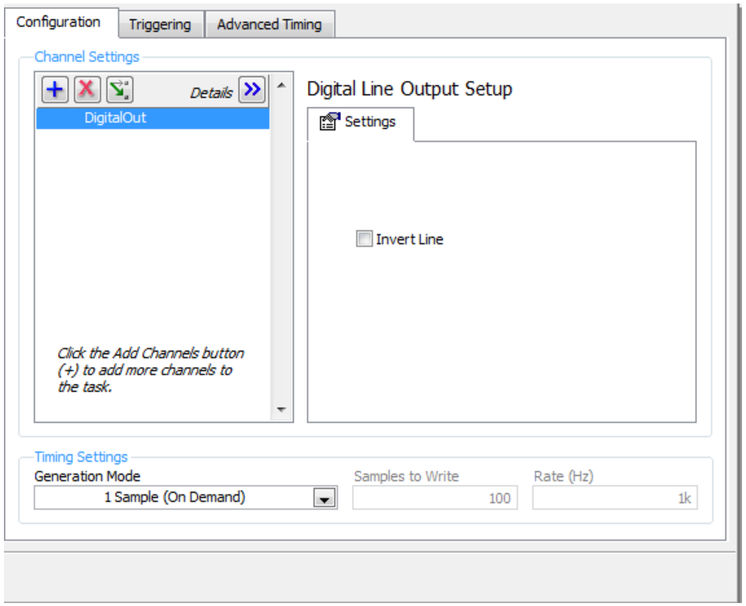
- The DAQ records the specified "Number" of samples at the specified "Rate", then you split the matrix and take a moving average to eliminate noise
- Number
  - Proportional to the precision of the recorded data
- Rate
  - How often you will record a data point



DAQ-6009

- For actuation, use the digital out pins
- This will output a 5V DC signal when the “data” input is true
- Use this for the linear actuator
  - Paintball hopper control is a bit more complicated, will go into detail later





Automation – Turntable

- The turntable is a LinearX Systems LT360EX
- Wired using a dedicated RS-232 cable (very reliable)
- LT360 software is very self explanatory

Automation – Turntable

- The platter has a bit of wobble in it so there is a large diameter rotational bearing attached on the same horizontal plane
- The rotational bearing stabilizes/levels using four thumb screws that connect to an 8020 frame
  - All of the 8020 connected directly to the turntable is precision leveled/drilled
  - Take care if modifying

Automation – Paintball Hopper

- http://www.amazon.com/Spyder-Paintball-9-Volt-Rapid-E-Loader/dp/B003BT2EUQ

Automation – Paintball Hopper

- Take the paintball hopper apart and you will find three main components:
  - DC motor (two wires)
  - Flex sensor at the output barrel (two wires)
  - Circuit board with the above two attached
- Disconnect the motor and flex sensor from the circuit board, and remove the circuit board
- You can wire the motor and sensor directly to the DAQ-6009
- You will want to connect the motor to a 9V power supply (you can use a phone charger or any other DC source) through an H-Bridge, which will be controlled by the DAQ
- The DAQ-6009 will then be able to control (on/off/direction) the paintball motor
- Using the sensor is optional. It is a flex-resistive sensor that will change resistance when a ball exits the hopper

Automation – Paintball Hopper

- **Here is the Toshiba H-Bridge schematic that we have used in the past:**

PIN FUNCTION

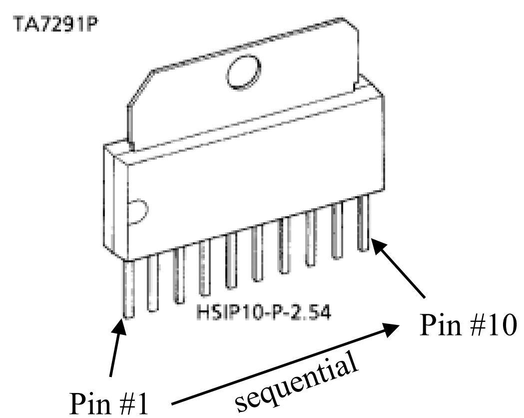
PIN No.			SYMBOL	FUNCTION DESCRIPTION	
P	S/SG	F/FG			
7	2	11	V_{CC}	Supply voltage terminal for Logic	5V from DAQ
8	6	15	V_S	Supply voltage terminal for Motor driver	9V from power source
4	8	5	V_{ref}	Supply voltage terminal for control	5V from DAQ
1	5	1	GND	GND terminal	Ground from DAQ + power source
5	9	7	IN1	Input terminal	DAQ digital output #1
6	1	9	IN2	Input terminal	DAQ digital output #2
2	7	4	OUT1	Output terminal	Motor lead #1
10	3	13	OUT2	Output terminal	Motor lead #2

P Type: Pin (3), (9): NC
S/SG Type: PIN (4): NC
F/FG Type: PIN (2), (3), (6), (8), (10), (12), (14), and (16): NC
For F/FG Type, We recommend FIN to be connected to the GND.

FUNCTION

INPUT		OUTPUT		MODE
IN1	IN2	OUT1	OUT2	
0	0	∞	∞	STOP
1	0	H	L	CW / CCW
0	1	L	H	CCW / CW
1	1	L	L	BRAKE

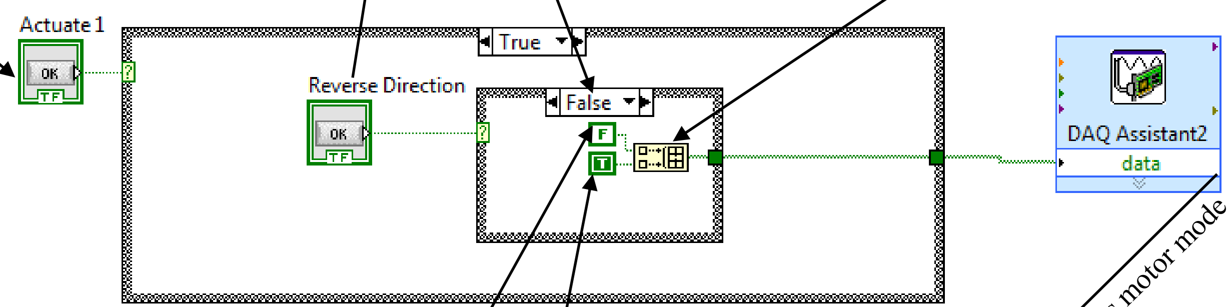
∞: High impedance
Note: Inputs are all high active type



http://www.toshiba.com/taec/components2/Datasheet_Sync/200706/DST_TA7291P-TDE_EN_3604.pdf

Automation – Paintball Hopper

- **Here is how the LabVIEW VI translates to paintball hopper actuation:**



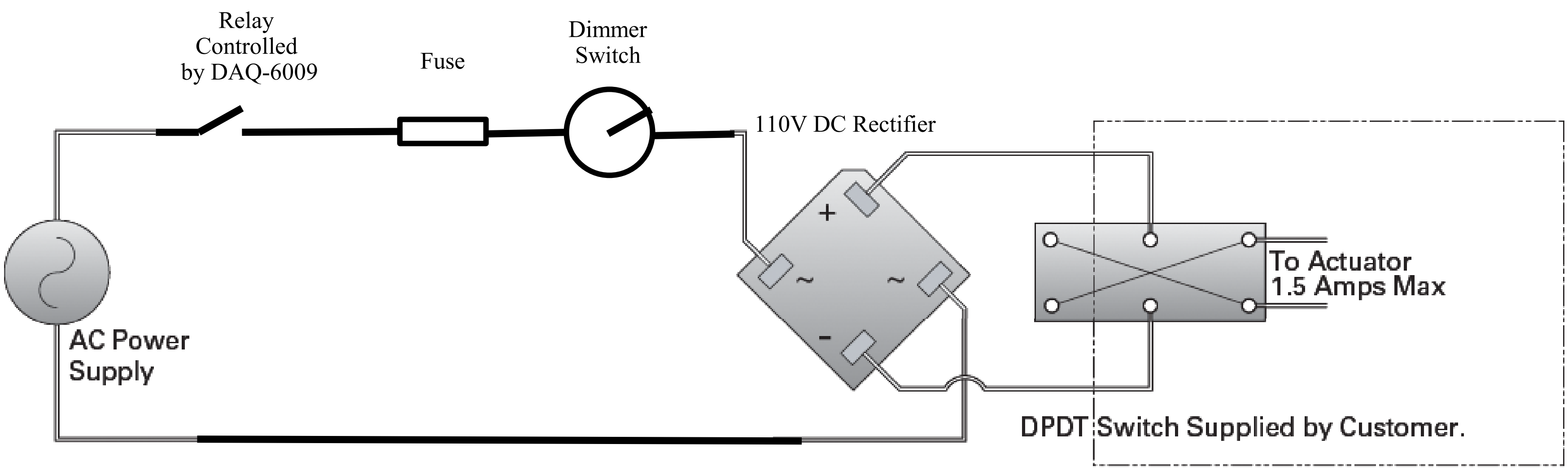
FUNCTION

INPUT		OUTPUT		MODE
IN1	IN2	OUT1	OUT2	
0	0	∞	∞	STOP
1	0	H	L	CW / CCW
0	1	L	H	CCW / CW
1	1	L	L	BRAKE

∞: High impedance
Note: Inputs are all high active type

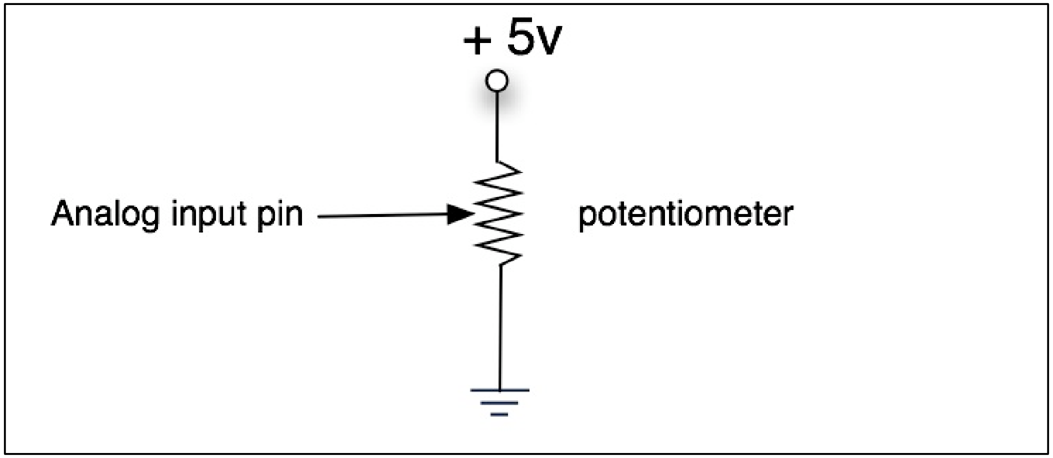
Automation – Linear Actuator

- The linear actuator is a simple DC motor (Nook Industries CC-18-HD E linear rod style actuator)
  - Powered by a DC-Rectified wall socket power source
  - ON/OFF controlled using a relay switch
  - Speed controlled using a dimmer switch (common to household lights)
  - Direction controlled using a DPDT switch
- <u>IF REWIRING THE ACTUATOR, UNPLUG FROM POWER SOURCE!!!</u>



Automation – Linear Actuator

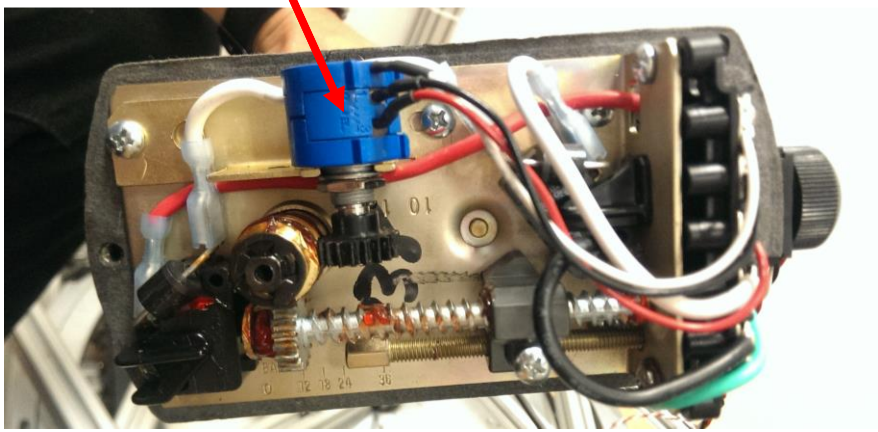
- The linear actuator has a built in potentiometer that interfaces with one of the worm screws
- The wires should never need to be disconnected from the actuator. They will need to be connected and reconnected from the DAQ-6009 often. Here's how they should be connected to the DAQ:
  - Red wire -> 5V
  - Black wire -> GND
  - White wire -> AI (zero usually)



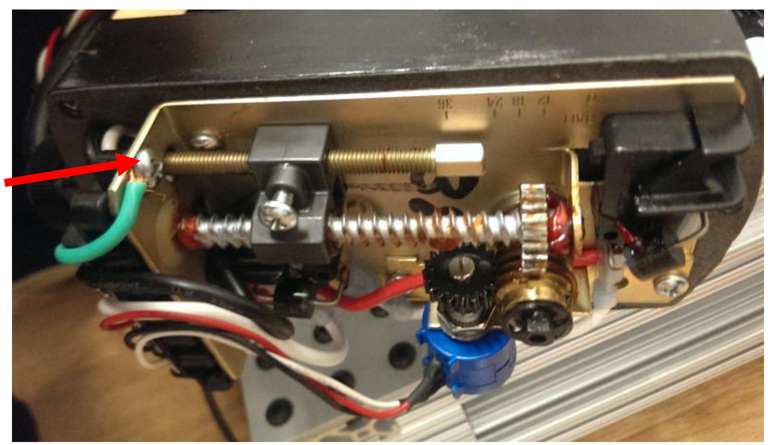
Automation – Linear Actuator

- **Here is what the wiring looks like when the bottom cover of the actuator is taken off:**

Potentiometer

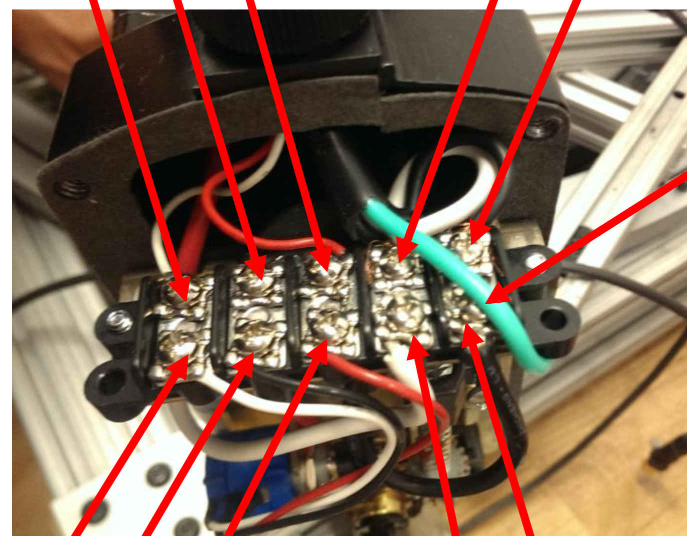


Ground
(from wall outlet
ground to
actuator housing)



White/Black/Red wires
From DAQ-6009
(connect to: AI/ground/5V)

Black/White wires
From power source
(connect to DPDT)



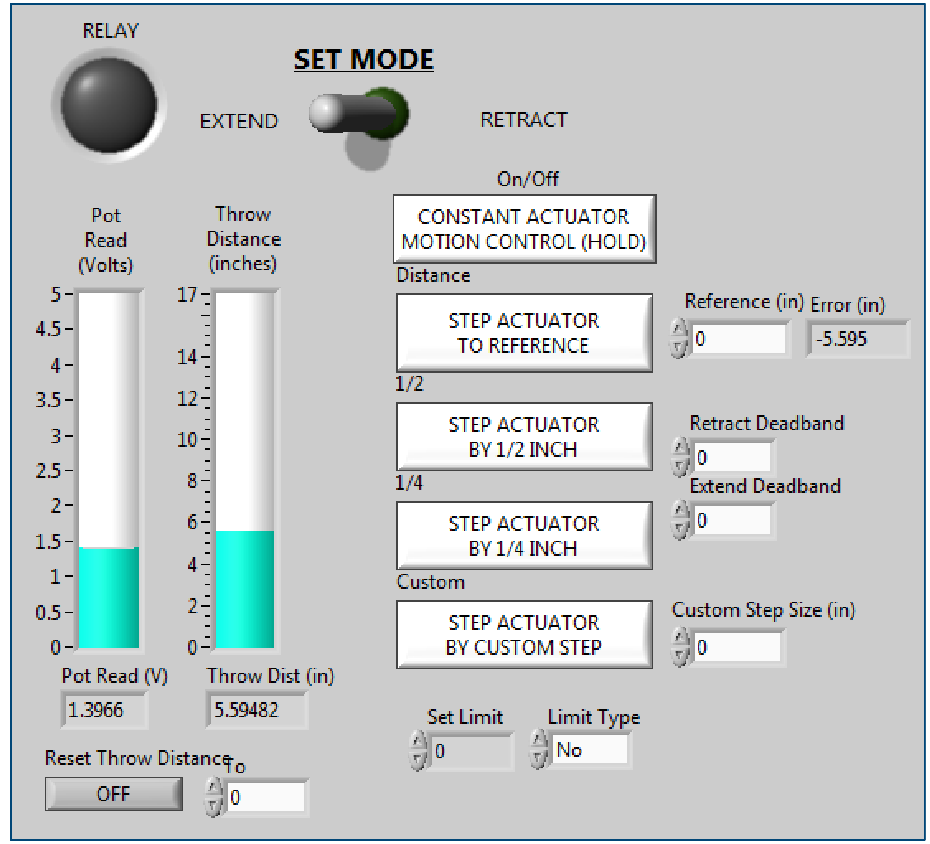
Ground
(green)

White/Black/Red wires
from Potentiometer
(connect to: AI0/ground/5V)

White/Black wires
from DC actuator motor

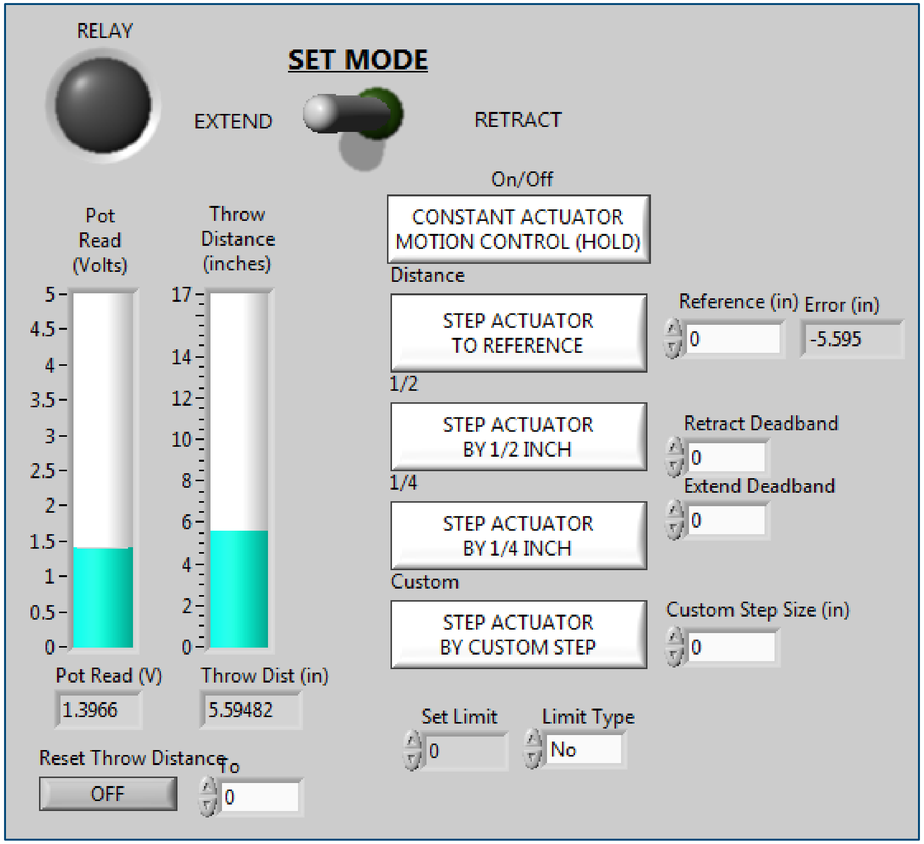
Automation – Linear Actuator

- Interfacing with LabVIEW
- Make sure “SET MODE” is set the same as the DPDT switch
  - You can set a reference location and move the actuator to that reference
  - You can also add a given step size to the reference
  - Reset throw distance will set your current location to a user-set value (zero the location or otherwise)
- USE THE SET LIMIT
  - Set in relation to the test section
  - Prevents the actuator from extending/retracting too far and breaking your experiment!



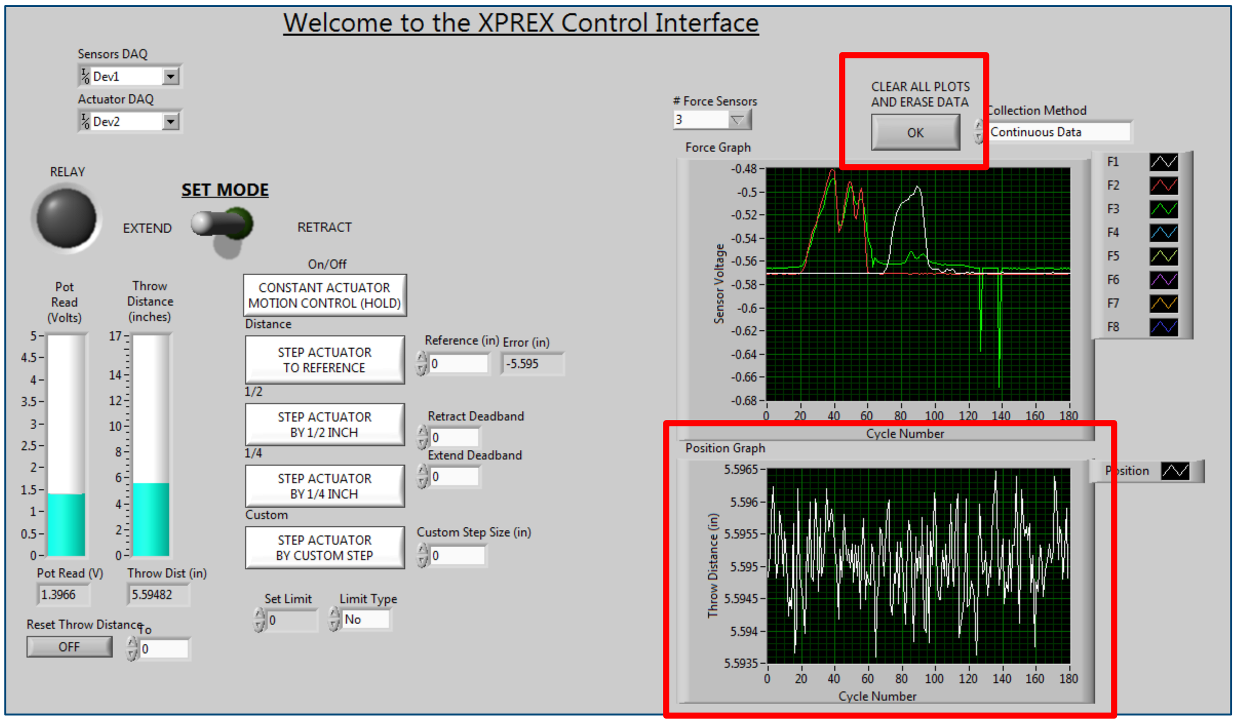
Automation – Linear Actuator

- Interfacing with LabVIEW
- The deadband is a distance measurement
  - The actuator will turn off when within the deadband distance from the reference
  - Should typically be set to ~0.07 inches



Automation – Linear Actuator

- Interfacing with LabVIEW
- The LabVIEW VI saves the locations of the actuator over your runtime
- Clear and erase data whenever you can
- Otherwise, the saved data gets passed through the program every cycle and will start to slow down the program after a long time



Automation – Linear Actuator

- The linear actuator works pretty well for step sizes down to ¼" and even 1/8". Precision is proportional to step size.
- If necessary, a good upgrade would be to get a DC motor controller capable of outputting PWM signals
- This would give precision control of the speed, and would also allow for a precision feedback system
- Asking CIET people about their variable speed drives may be useful
  - For more on PWM control: http://www.allaboutcircuits.com/textbook/semiconductors/chpt-11/pulse-width-modulation/

Installation Procedures

- The 80/20 schematics should be posted on the internal XPREX wall and should be sufficient to build any necessary test stands
- The linear actuator must be uninstalled when building the cylindrical silo test setup
  - The +, - and GND wires must be disconnected from the actuator by removing the actuator's lower cover and unscrewing the terminals
  - Always remember what went where (use tape to mark)
  - The wires are then removed through the center of the turntable
  - The potentiometer leads should remain connected to the actuator, disconnect at the DAQ-6009
- Threading wires through the center of the turntable can sometimes be difficult
  - A good trick is to tie small 24 gauge hookup wire to the cables that need to go through the turntable center
  - The 24 gauge wire is much easier to work with, and much easier to get through the turntable center
  - The use of hooks and pliers is encouraged

Installation Procedures

- To move the x-ray detector:
  - This is a two person job
  - Have a person on either side of the detector, each with an 80/20 hex screwdriver
  - Loosen one bolt at a time, while supporting the detector weight on both sides
  - One bolt is actually sufficient to hold up the detector, once the last bolt is loosened, the detector will be free to slide (and to fall, be careful!)
  - Slide the detector to the desired height and tighten a single bolt
  - Use a precision level before you tighten a 2nd bolt such that a bolt is tight on either side with the detector VERY level
    - » A level detector is critical for digital tomography
    - » This is worth spending an extra 10 minutes on to get perfect

Installation Procedures

- **To move the x-ray collimator:**
  - This is a two or three person job
    - » (or just have James do it, he's strong)
  - The collimator is much heavier than the detector
  - One person on either side with screwdrivers supporting weight with an (optional) third person supporting weight in the middle is ideal
  - A procedure similar to the detector is used, except:
    - » Precision level is not as necessary, as the actual collimator can rotate
    - » When you get the collimator to the ideal height, lock it down and just level the rotating part of the collimator

Best of luck and always feel free to contact Grant Buster

720-495-6245

grant.buster@gmail.com