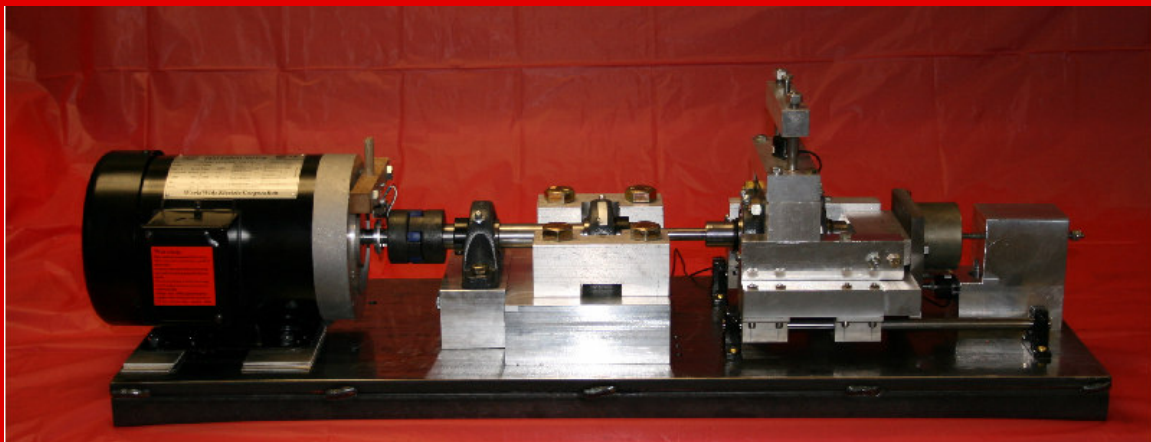




**Cummins 2**



## **Fatigue Tester Operations Manual**



Department of Mechanical Engineering  
**EML 4551 Senior Design Project**  
**Dr. Cesar Luongo**



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## **Table of Contents**

Purpose.....	3
Safety Precautions.....	3
Test Procedure .....	4
How to run a test.....	4
Cummins Inc. RBF Test Rig.....	9
Data Acquisition and Control System.....	9
User's Guide .....	9
 Safety Instructions  .....	10
USB-6009 DAQ Board Channel Configuration .....	10
Connecting sensors to the USB-6009 DAQ Board.....	11
LabVIEW Virtual Instrument Software.....	13
Running the LabVIEW Virtual Instrument Software .....	14

## ***Purpose***

The purpose of the CL-12 is to perform Rotating Bending Fatigue (RBF) Testing, Tensile Fatigue Testing, and/or a combination of the two in order to produce data that can be used to predict trends in metals.

## ***Safety Precautions***

1. Safety goggles should be worn during machine operation.
2. Check CL-12 for loose or damaged nuts and bolts. Tighten all loose nuts and bolts and replace any damaged nuts and bolts (reference Appendix A).
3. Make sure the CL-12 is on a level sturdy surface before testing.
4. Place safety box over CL-12 before testing begins and keep the box over the CL-12 during all testing.
5. Make sure power outlet being used can safely handle the electrical components of the CL-12.
6. Relubricate bearings 2 times per year

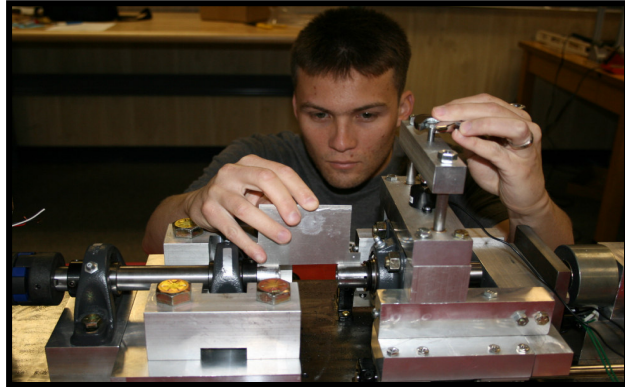
## Test Procedure

### How to run a test

#### Tensile loading only:

##### Step 1)

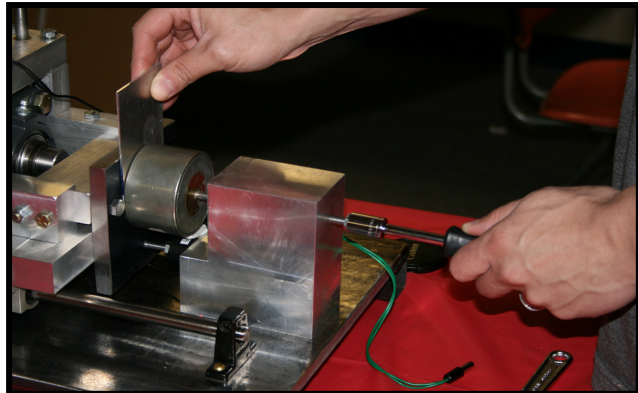
Begin by making sure that everything is turned off. Adjust the vertical loading bolt so that the right grip and the main shaft are aligned.



##### Step 2)

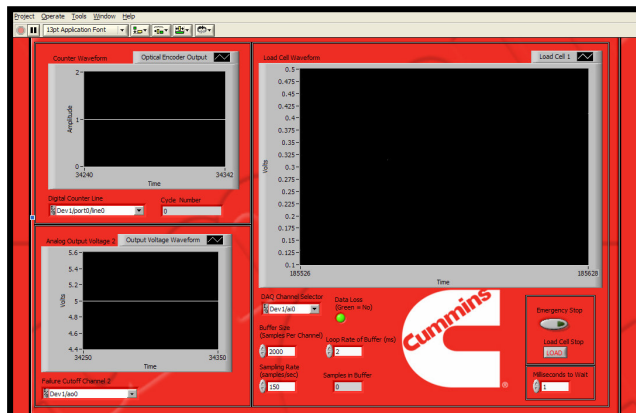
Using the spacer plate, adjust the tensile loading bolt or the magnet adjustment screw so that the electromagnet is a set distance from the steel plate. Be sure not to tangle the power chord. Note that the tensile loading bolt must always be flush with the load cell when running a test.

**Note:** Counter Clockwise Extends Electromagnet



##### Step 3)

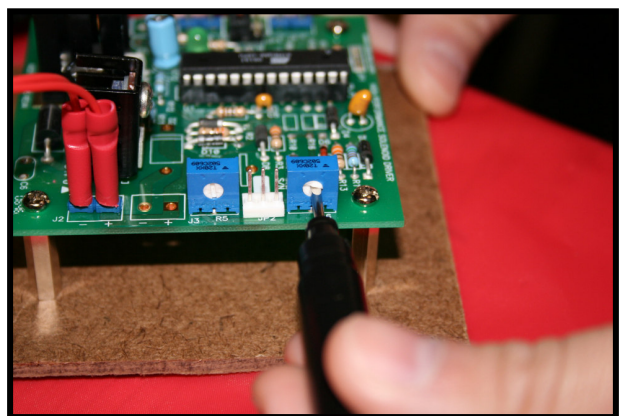
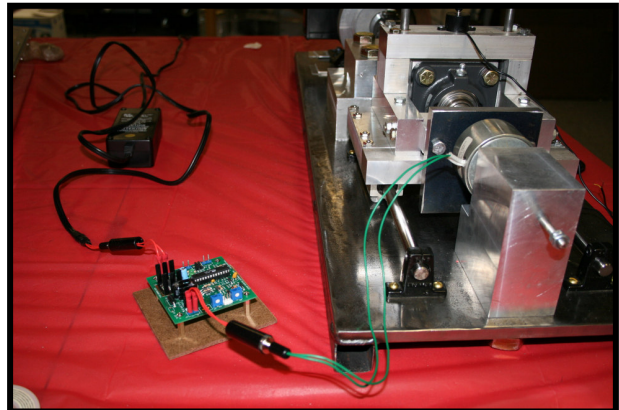
Start Labview in accordance with attached instructions.



**Step 4)**

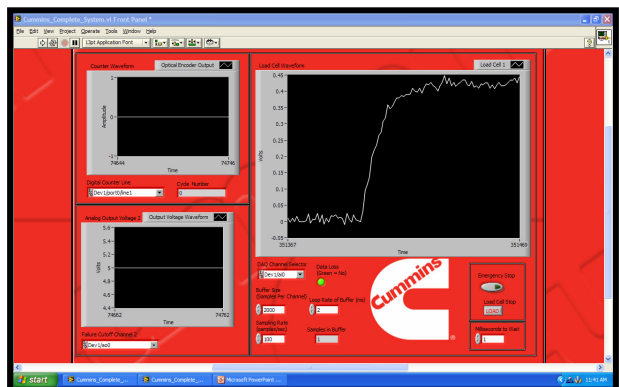
Plug in the electromagnet power supply and adjust the power cycler to the lowest frequency setting.

**Note:** Counter Clockwise Decreases Frequency.



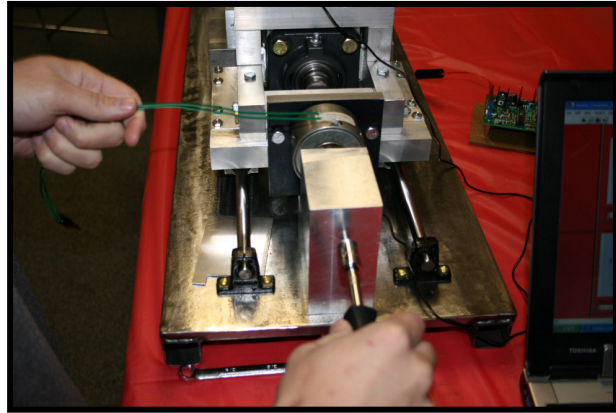
**Step 5)**

Using Labview, record the magnitude of the force (or voltage, from which force can be calculated) being applied to the load cell. This is for calibration purposes.



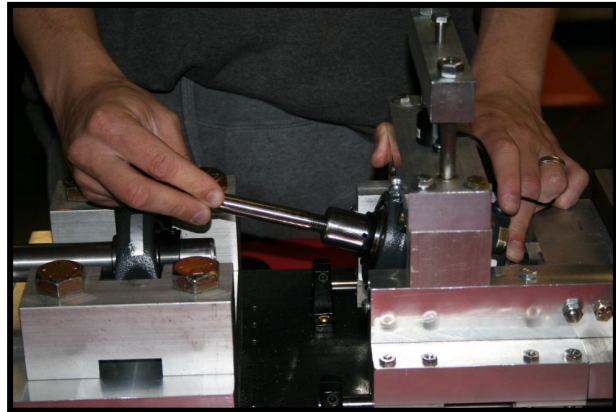
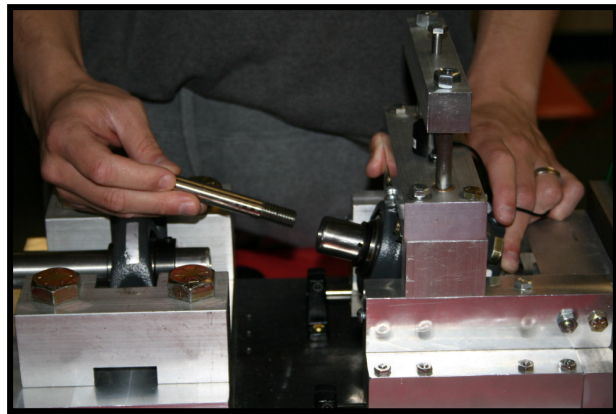
**Step 6)**

Unplug the electromagnet power supply. Retract the electromagnet and tensile load bolt.



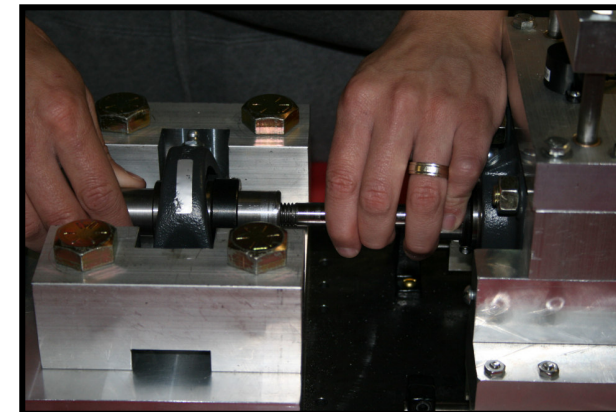
**Step 7)**

Tilt the right grip so that the opening is facing up. Insert the specimen into the right grip and turn clockwise to tighten. Lower the right grip and align the specimen with the opening in the end of the main shaft. It may be necessary to remove the rear steel plate in order to insert or remove specimens.



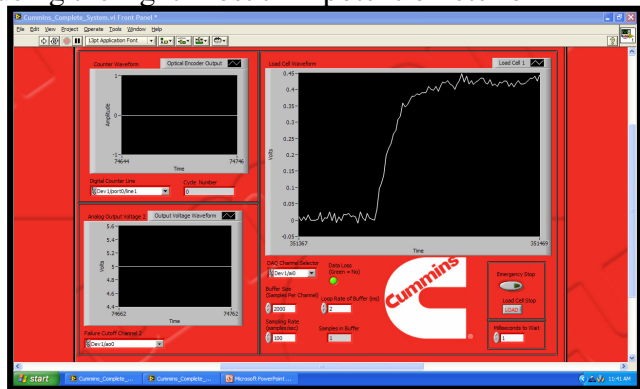
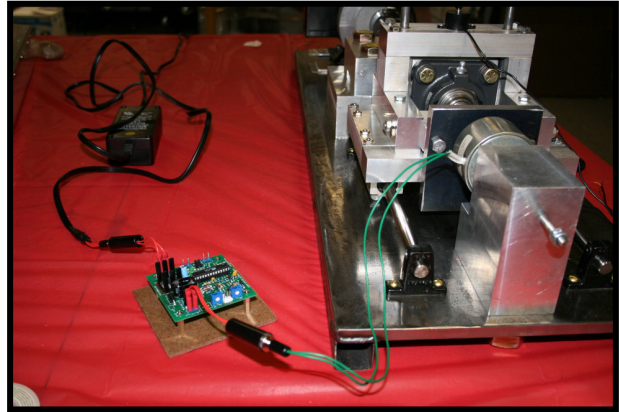
**Step 8)**

Move the platform so that the specimen is inserted into the main shaft. Rotate the main shaft so that the specimen is threaded into the shaft and tightened.



### Step 9)

Adjust the electromagnet and/or tensile loading bolt so that the electromagnet face is the same distance from the steel plate as it was during the calibration stage (again, use the spacer plate). Plug the electromagnet power supply back in and read the loading that is recorded by Labview. The difference between the reading taken before the specimen was loaded and this reading is the load being applied to the specimen. Start a new “test” in Labview and adjust to the desired frequency of the electromagnet cycle using the right-most trim potentiometer on the On/Off Power Cycler. Be sure to keep the frequency low enough that the sensor and software can distinguish between cycles.



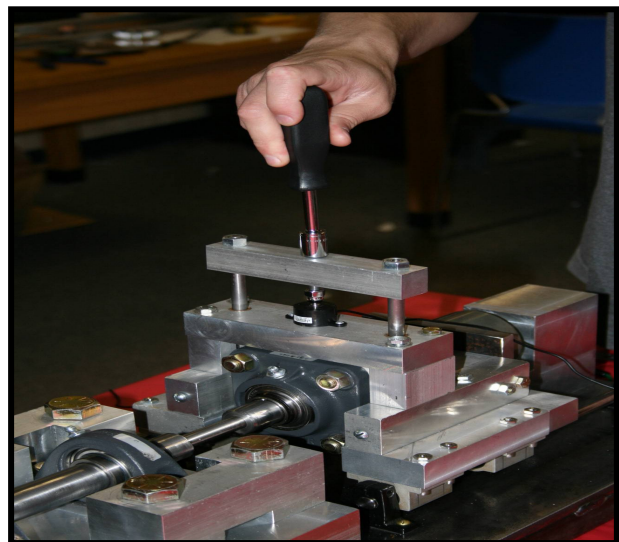
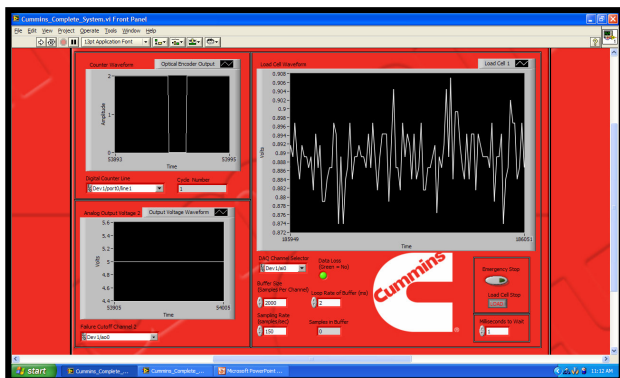
### Testing Complete

Once the test is completed, unplug the electromagnet power supply. Then remove the specimen (or specimen fragments) from the main shaft and right grip.

### Rotating-bending only:

#### Step 1)

To perform the Rotating-Bending test, begin by making sure that everything is turned off. Adjust the vertical loading bolt so that the right grip and the main shaft are aligned.

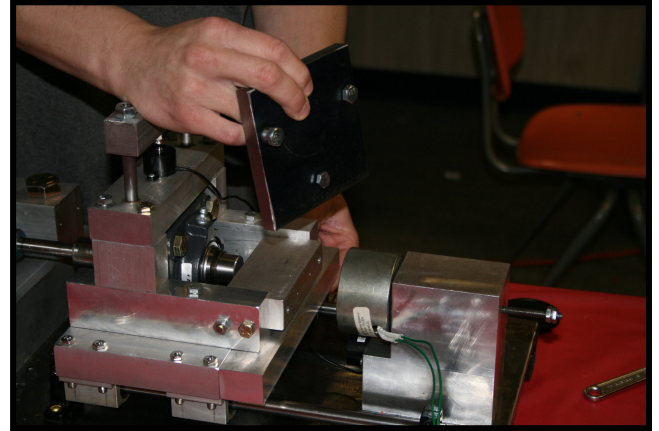


### Step 2)

Follow **Step 7** of tensile loading instructions.

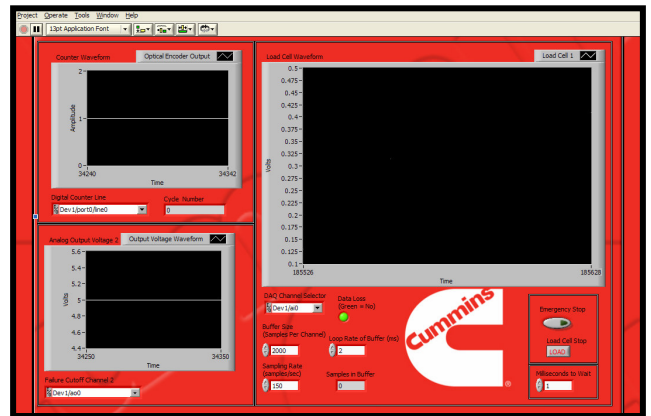
### Step 3)

Plug in the motor. Start the motor using Labview, and increase to top speed for two minutes. This is to allow the bearing lubrication to warm up. Remove the specimen blank and replace it with a specimen, following the same procedure as before. Note: it may be necessary to remove the rear steel plate in order to insert or remove specimens and specimen blank.



### Step 4)

Check to make sure that the vertical load is the same as it was with no specimen. Adjust the vertical load bolt in order to increase the vertical load (the difference between the no-specimen load and this reading is the actual bending load being applied to the specimen). Restart the data acquisition in Labview and plug in the motor.



### Testing Complete

Allow the test to run until failure or until the desired number of cycles has been reached. Unplug the motor and remove the safety box. Then remove the specimen (or specimen fragments) from the main shaft and right grip.

### Combined loading (tensile and rotating-bending):

Follow the procedures for each mode, making sure to use the specimen black to warm up the bearings first.



***Cummins Inc. RBF Test Rig  
Data Acquisition and Control System  
User's Guide***



**Created By: Kevin Garvey  
Date: March 29, 2007**

## Introduction

This manual outlines the proper setup and usage of the NI USB-6009 DAQ board and the associated LabVIEW virtual instrument (VI) software designed specifically for use with the Cummins Inc. RBF test rig.



## **Safety Instructions**

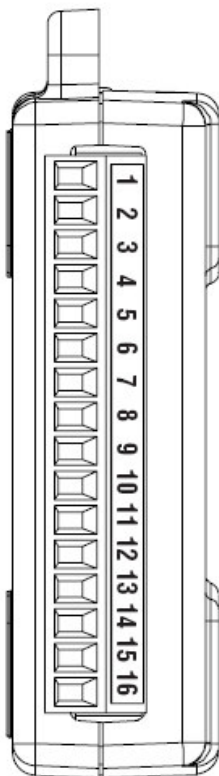


**DO NOT** connect the USB-6009 to the USB Hub on the computer interface until all sensors have been connected to the USB-6009 and checked for correct orientation.

The USB-6009 outputs **5 Volts DC at 8.5 mA** max. Take precaution when connecting and disconnecting wires.

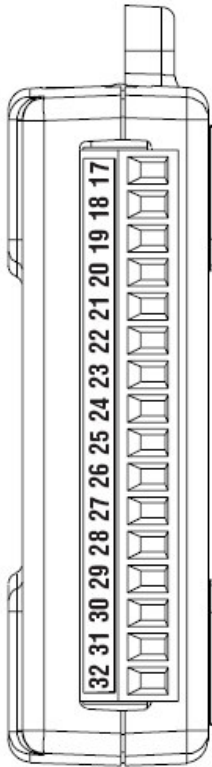
## **USB-6009 DAQ Board Channel Configuration**

The following diagrams outline the specific channel lines and their accompanying LabVIEW program reference title.



Channel	Reference	LabVIEW Channel Reference
1	Ground	N/A
2	Analog Input	AI 0
3	Analog Input	AI 4
4	Ground	N/A
5	Analog Input	AI 1
6	Analog Input	AI 5
7	Ground	N/A
8	Analog Input	AI 2
9	Analog Input	AI 6
10	Ground	N/A
11	Analog Input	AI 3
12	Analog Input	AI 7
13	Ground	N/A
14	Analog Output	AO 0
15	Analog Output	AO 1
16	Ground	N/A

**Figure 1: USB-6009 Analog Channels**

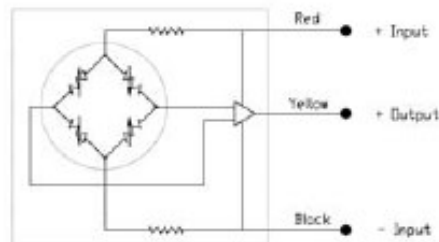


Channel	Reference	LabVIEW Channel Reference
17	Digital Port/Line	P0.0
18	Digital Port/Line	P0.1
19	Digital Port/Line	P0.2
20	Digital Port/Line	P0.3
21	Digital Port/Line	P0.4
22	Digital Port/Line	P0.5
23	Digital Port/Line	P0.6
24	Digital Port/Line	P0.7
25	Digital Port/Line	P1.0
26	Digital Port/Line	P1.1
27	Digital Port/Line	P1.2
28	Digital Port/Line	P1.3
29	Counter Input	PFI0
30	+2.5VDC	N/A
31	+ 5VDC	N/A
32	Ground	N/A

**Figure 2: USB-6009 Digital Channels**

### ***Connecting sensors to the USB-6009 DAQ Board***

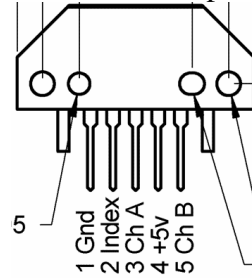
Various sensors may be connected to the USB-6009 DAQ board. The RBF test rig only requires the connection of 2 Load Cells, 1 Optical Encoder, and 1 Electromechanical Relay. Below is the procedure for connecting these sensors to the board.



**Figure 3: Load Cell Schematic (FC22 Type)**

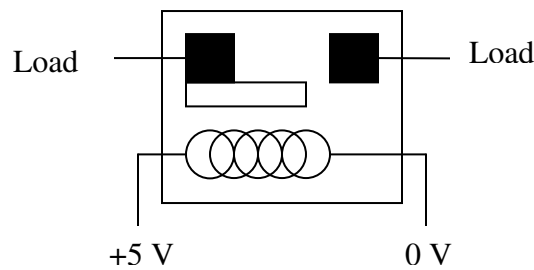
- Load Cell Connection
  1. Connect Red Power Wire to Port 31 (See figure 3 above)

2. Connect Yellow Signal Wire to Analog Port 2
3. Connect Black Ground Wire to port 32



**Figure 4: Optical Encoder Schematic (HEDS Type)**

- HEDS Optical Encoder Connection
  1. Connect +5V to Port 31 (See figure 4 above)
  2. Connect Index to 17 and 29 in parallel
  3. Connect Gnd to Port 32



**Figure 5: Relay Schematic (Reed Type)**

- Reed Relay Cutoff Circuit Connection
  1. Connect +5V to Port 31 (See figure 5 above)
  2. Connect Load in series across motor power wire
  3. Connect 0V to Port 32

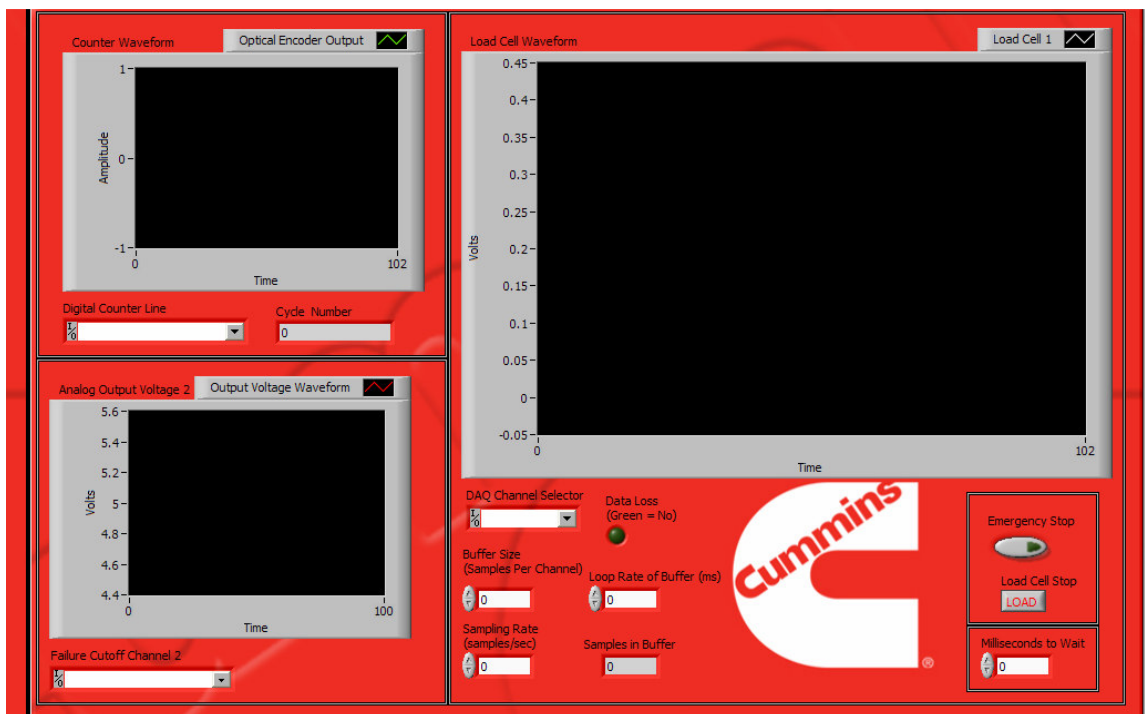
**Important Note:**

After connecting all sensors, ensure that all channels are properly connected and that no short circuits are present. Before connecting the USB-6009 to the computer,

check to make sure that no wires will bind or become pinched by the RBF test rig during the testing process.

## ***LabVIEW Virtual Instrument Software***

- Ensure that all electrical sensors are correctly oriented and connected into the USB-6009 DAQ board.
- Connect the DAQ board to the USB hub into the computer interface.
- Finally, turn on computer and open the LabVIEW VI program titled **Cummins Complete System.vi**



**Figure 6: LabVIEW VI Screenshot**

### **Program Description**

- Counter Waveform (Upper Left Box)
  - The upper left box of the program shows the cycle count number and the associated waveform from the optical encoder.
- Cutoff Channel Waveform (Lower Left Box)
  - The lower left box outlines the waveform from the analog output signal. This channel outputs a constant 5 Volts DC when no failure is present and outputs 0 Volts when a failure occurs.

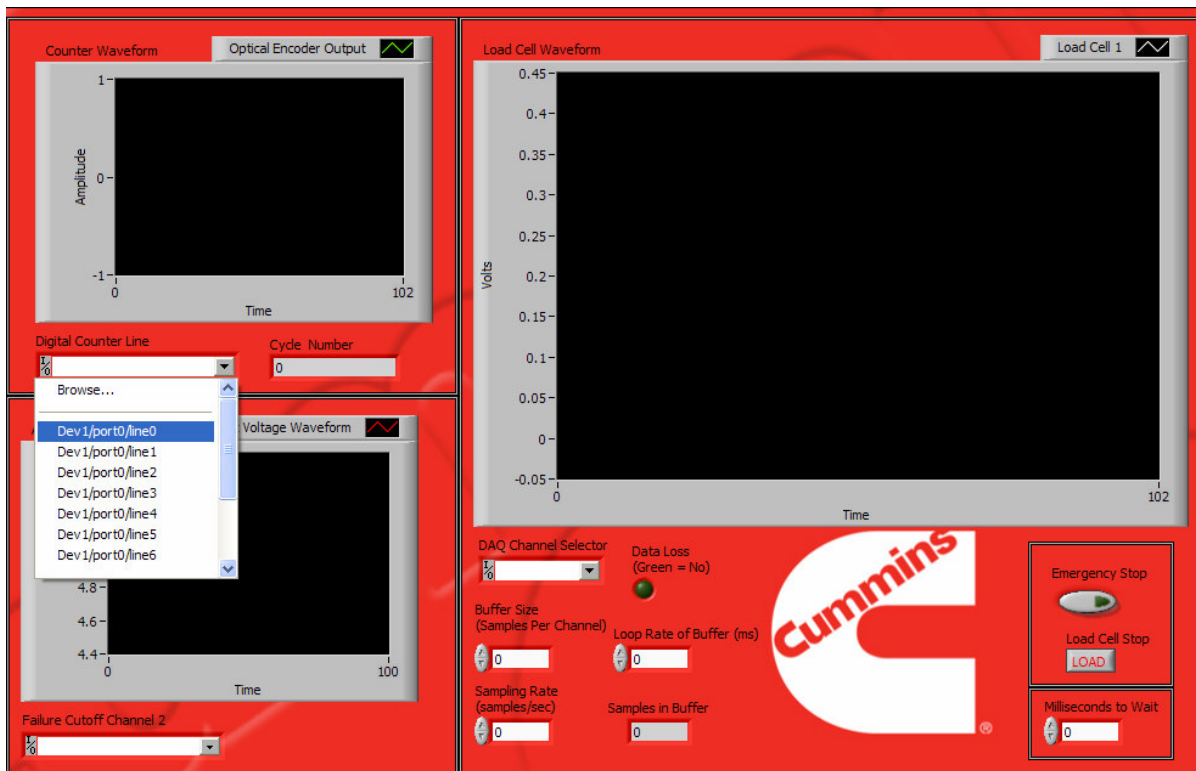
- Load Cell Waveform (Right Box)
  - The right box shows the load cell waveform which outputs the load signals from the associated channels.
- Emergency Cutoff Circuit (Lower Right Box)
  - The lower right box contains the emergency stop button for emergency cutoff of the entire RBF system as well as the LabVIEW program.
  - This circuit also contains an option to connect/disconnect certain load cell channels during a test.

## ***Running the LabVIEW Virtual Instrument Software***

To run the Cummins Inc. LabVIEW VI program, the following steps need to be followed before starting the program.

### **Assigning Channels:**

- 1.) Pull down the drop down menu in the counter waveform box and select Dev1/port0/line0 (as seen in figure 7 below)
- 2.) Pull down the drop down menu in the analog output box and select Dev1/ao0
- 3.) Pull down the drop down menu in the load cell box and select Dev1/ai0

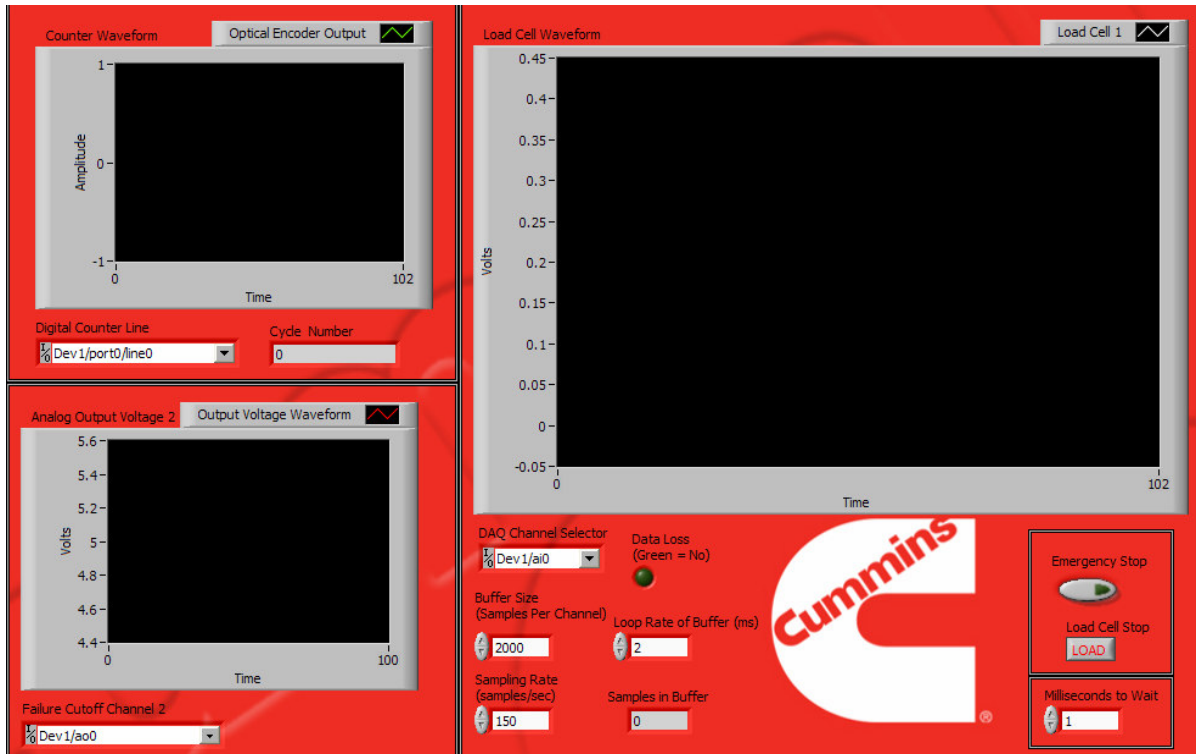


**Figure 7: Assigning Channels in LabVIEW VI**

### Setting the Buffer configuration:

A buffer has been setup within the LabVIEW VI such that the sample rate can be set so the USB-6009 DAQ Board will not become over saturated and begin to lose data. To set the buffer the following steps need to be followed:

- 1.) Under the “Buffer Size,” set the samples per channel, at the most, to 2000.
- 2.) Under “Sampling Rate,” set the samples/sec to 150 at the most.
- 3.) Under “Loop Rate of Buffer,” set the ms to 2 at the most.
- 4.) Also, set the “Milliseconds to Wait” to 1. (Reference figure 8 below)



**Figure 8: Buffer Configuration**

### Important Note:

The buffer has a circuit which constantly checks against data loss. A **GREEN** indicator light means that NO data is being lost. If the indicator light is off, then data loss is occurring and the sampling rate needs to be decreased. The USB-6009 DAQ board has a 32 bit internal buffer that is constantly overwritten by this software buffer. If at any time during the testing a 32 appears in the “Samples in Buffer” box, then data is being aliased into the real-time display and the test data is compromised.

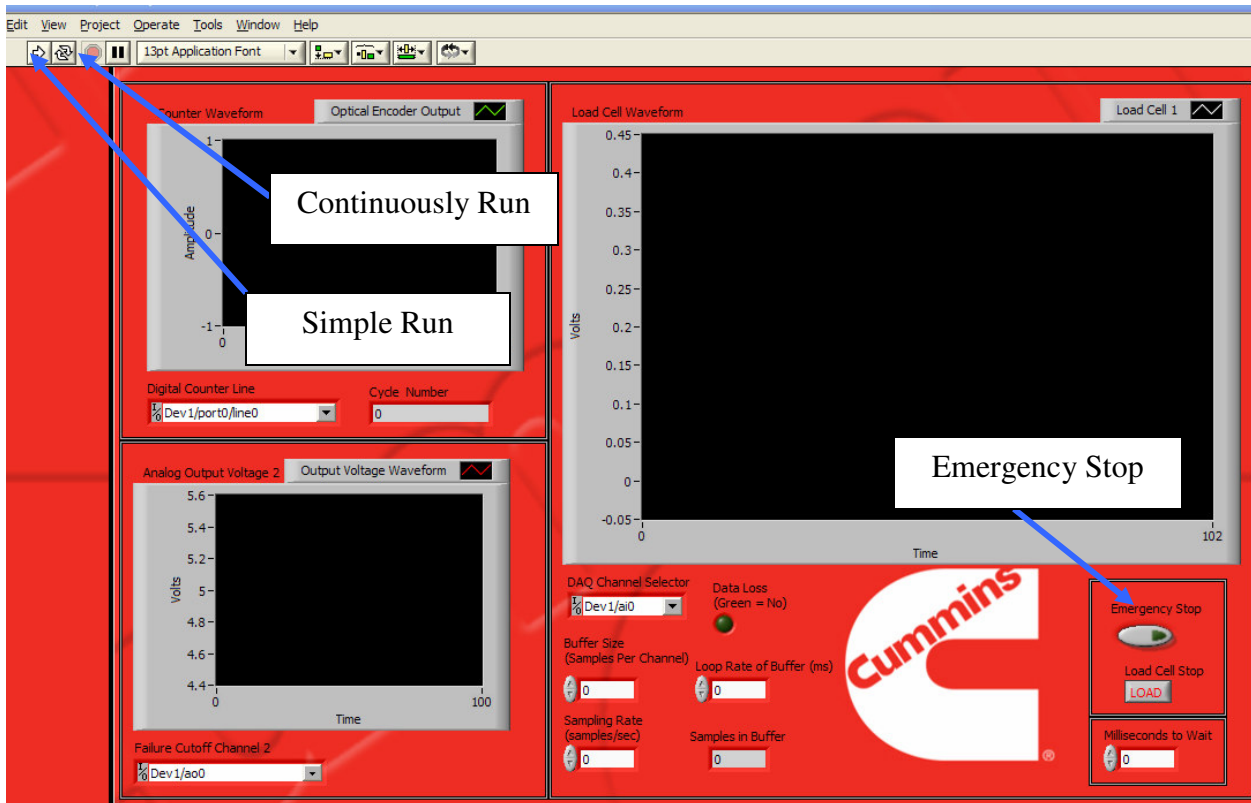
## Running the VI and Emergency Cutoff Circuits:

There are 2 modes that the VI can be configured for: Simple Run or Continuously Run.

- 1.) First choose Simple Run as seen in figure 9 below.
- 2.) Once the program begins running and no errors have been found, then the Continuously Run option should be selected. (See Figure 9 below)

### *Emergency Stop Cutoff*

If for any reason the system needs to be cutoff from a remote distance from the RBF test rig, an emergency stop cutoff circuit has been added for safety. See figure 9 below for the location of the emergency stop cutoff button.



**Figure 9: Run Modes and Emergency Cutoff**