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Dynamic Muscle Control 610A

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Table of Contents

1	Introduction	6
2	Quick Start Guide	7
	2.1 <i>Instrument Setup</i>	7
	2.1.1 Turning on the PC and Using the Desktop	7
	2.1.2 Starting the 610A DMC Program	8
	2.2 <i>Using the 610A DMC Program</i>	9
	2.2.1 Configuring DMC	9
	2.2.2 Creating a Protocol	10
	2.2.3 Running an Experiment	11
3	General Operating Procedure	13
	3.1 <i>Main Screen</i>	13
	3.1.1 Graphics Window	13
	3.1.2 Control Buttons	14
	3.1.3 Text Readout Boxes	16
	3.1.4 Test Progress and Status Line	16
	3.2 <i>Main Menu</i>	17
	3.2.1 File Menu	17
	3.2.2 Setup Menu	17
	3.2.3 Protocol Editor	21
	3.2.4 Sequence Editor	25
	3.2.5 Help Menu	27
	3.3 <i>Live Data Monitor</i>	27
	3.3.1 Using Live Data Monitor	28
	3.4 <i>Analysis</i>	29
	3.4.1 Using the Analysis Window	30
4	Calibration, and Software Maintenance	33
	4.1 <i>Calibration Editor</i>	33
	4.1.1 Calibrating Length	33

4.1.2	Calibrating Inputs – Force In/Temp In/3 rd Party In	34
4.1.3	Calibrating Force Out.....	35
4.2	....<i>Software Activation</i>	36
4.3	....<i>Updating to a New Version of the 610A DMC Program</i>	37
5	Performance Guarantee, Technical Support, Warranty and Repair Information	38
5.1	....<i>Performance Guarantee</i>	38
5.2	....<i>Technical Support</i>	38
5.3	....<i>Technical Support Contact Information and Return Shipping Addresses</i>	38
5.4	....<i>Warranty</i>	39
5.5	....<i>Returning Products to Aurora Scientific for Repair</i>	40
6	Specifications	42
7	Appendices.....	43
7.1	....<i>Appendix A – 610A Data File Structure</i>	43
7.2	....<i>Appendix B – 610A Protocol File Structure</i>	43
7.3	....<i>Appendix C – 610A Sequencer File Structure</i>	44
7.4	....<i>Appendix D – 610A Log File Structure</i>	44

1 Introduction

The 610A Dynamic Muscle Control (DMC) software was designed to enable physiology researchers to study the dynamic mechanical characteristics of muscle tissue. The system is capable of controlling and taking data from all of our 300C series muscle levers, our 400A series of force transducers and our 700A series of stimulators. The 610A software can also be used with other manufacturer's instruments. A unique feature of our 610A software is its ability to create arbitrary length, force, and stimulation control signals. You are not limited to simple square waves, sine waves, or fixed-frequency stimulation.

DMC has an easy-to-use graphical user interface and is written using the LabVIEW programming language. The software collects high-resolution length and force data while controlling the length and force of the muscle tissue under test. Collected data can then be plotted and analyzed within the program. The 610A program also includes a real-time scrolling display of the current length and force. This scrolling display can be frozen at any time and then up to 30 minutes of data can be reviewed.

The 610A software was designed for use with a National Instruments PCI-6221 card, though it will work with a wide range of National Instruments DAQ products. This card features 16-bit accuracy on the eight differential analog input channels (A/D) and on the two analog output channels (D/A). The use of a 16-bit A/D and D/A ensures that the 610A Dynamic Muscle Control measures and controls length and force to the resolution of our instruments.

Officially, we support the following NI DAQmx devices:

- 1) PCI-6221 (M-series Multifunction DAQ for PCI bus)
- 2) PCIe-6321 (X-series Multifunction DAQ for PCI Express bus)
- 3) USB-6259 (M-series Multifunction DAQ for USB bus)

There are many more NI devices which may be compatible with DMC. In general, DMC requires a National Instruments device that meets the following criteria:

- 1) 8 or more differential analog inputs with a +/- 10V range
- 2) 2 or more analog outputs with a +/- 10V range
- 3) Hardware timed Digital I/O on Port 0


2 Quick Start Guide

The Quick Start Guide will help you set up and start using your new software by explaining how to complete some of the most common tasks. In order to get the most out of your new Dynamic Muscle Control software we recommend that you read this entire manual.

2.1 Instrument Setup

The 610A Dynamic Muscle Control Software should have been shipped to you on a DVD Disc labeled “615A Dynamic Muscle Control and Analysis Software Suite”.

Place the PC to be used with the DMC software near the measurement electronics. The normal criteria for locating a PC should be followed including ensuring adequate ventilation for cooling along with protection from water, dust, dirt, vibration and shocks. Install the A/D Card into the PC, and install the software from the DVD by inserting the DVD into the DVD drive on your PC and following the on-screen directions.

 *NOTE: If you purchased the DMC software with a 601A Windows PC then both the PC and DMC were completely configured at our factory and you do not need to install any software.*

The DMC software runs under Windows, and therefore most Windows compatible software should run without issue on the same PC with DMC. However, we do not recommend running other software at the same time as DMC due to the performance requirements of DMC.

See the 604A A/D Signal Interface Manual for instructions on connecting your dual-mode lever system (or a length controller and force transducer) and stimulator to the 604A A/D Signal Interface. The 604A comes with all the cables required to make these connections. The 604A manual also provides instructions on connecting the ribbon cable from the back of the 604A Interface to the A/D card located in the PC.

2.1.1 Turning on the PC and Using the Desktop

Once all components of the system have been connected together in the correct manner turn on the PC (power switch is located on the front panel). Turn on the monitor as well. The PC should go through the normal power on self-tests and then the Windows operating system should be loaded.

After installing the DMC software via the DVD, you will find the following icons on the Windows Desktop:

DMCv5.500:	Used to start the Dynamic Muscle Control Software.
DMAv5.300:	Used to start the Dynamic Muscle Analysis Software.
NI MAX:	Used to start the National Instruments Measurement and Automation Explorer tool. This tool allows you to verify correct operation of the A/D Card in the event of system malfunction.
DMCv5 Example Protocols:	A file folder containing example protocols for DMC.

 *NOTE: Version numbers may not match exactly with the ones found here.*

2.1.2 Starting the 610A DMC Program

To start the 610A program click on the icon labeled DMCv5.500. When the program starts you may be asked to activate the software before continuing. If so, please refer to Section 4.2 Software Activation found later in this manual to activate your software, and then return to this section.

Once you've activated your copy of 610A, you will be presented with the main window. This window can be repositioned, maximized, minimized and stretched using the normal Windows controls for manipulating the display window. The main page provides access to all of the menu items and also contains a large graphing area for the display of data taken during a test. A menu bar is located along the top of the screen that includes the following main menu headings.

File Setup Protocol Sequencer Help

Clicking on any menu item opens a drop-down menu that lists the commands available under the selected heading. A detailed description of each command is provided in Section 3 *General Operating Procedure*

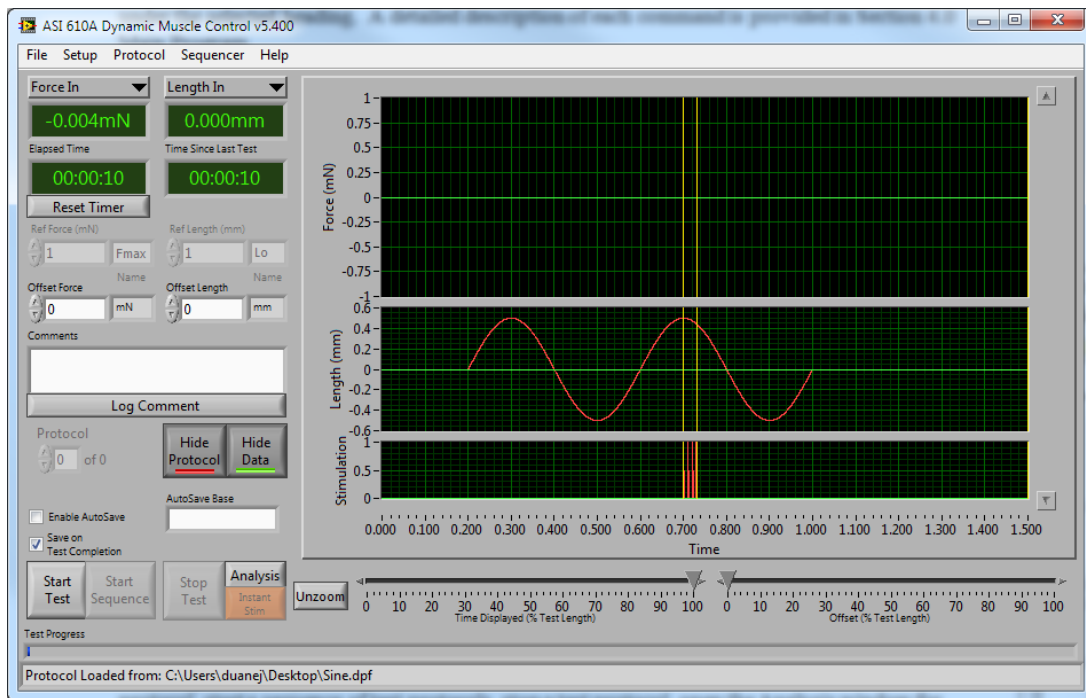


Figure 1: DMC Main Window

Located near the bottom of the main screen are a series of buttons labeled: Start Test, Start Sequence, Stop Test, Analysis and Instant Stim. These buttons are used to start a test protocol, start a sequence of test protocols, stop a test protocol, open the Analysis window for basic analysis of the data acquired, and produce stimulation pulses at the click of a button, respectively. Located near the top left of the window are two text readout boxes that display the current values of selected input channels. Each of these text readouts can be set to show either: Length In, Force In, Aux 1, Aux 2, Aux 3, Aux 4, Aux 5 or Aux 6. Below the channel readouts are two timers which show Elapsed Time since the program was started, and time since the last test was completed. The units for all channels are set using the Setup>Channel Setup menu. At the bottom of the window is a box that displays status messages.

2.2 Using the 610A DMC Program

This section will cover the main steps required to set up an experiment, control a dual-mode lever system and take some data. For this example we will assume that the user has a 300C dual-mode lever system. If your instruments are different, simply substitute your actual model number in the instructions.

Please note that if you are connecting the 610A Dynamic Muscle Control to a dual-mode lever system then you will be able to control and measure both length and force. However, if you are using a separate force transducer and length controller then you will not be able to control force. If you require this ability then please consider using our 600A software which can provide force feedback control when using a separate length controller and force transducer.

Your instruments should be connected correctly to the 604A Signal Interface (if not, see Section 2.1 *Instrument Setup* in this manual). If you are electrically stimulating the muscle tissue then ensure that the stimulator is also connected correctly. It is recommended that while you are becoming familiar with the program you use an elastic (rubber) band instead of using actual muscle tissue.

2.2.1 Configuring DMC

Before an experiment can be run, DMC must first be configured. In order to scale data correctly, DMC must know what instruments are connected. The following procedure will configure DMC for a simple 300C configuration.

- 1) Turn on the PC, log in, and start the 610A DMC Program (see Section 2.1.2 *Starting the 610A DMC Program* for further detail).
- 2) Click on Setup > My Instruments
- 3) Add your instruments to the list using the controls at the bottom of the My Instruments window.
- 4) Select the instrument model using the pull-down menu, and then enter the serial number of the instrument to provide a unique identifier for it. DMC is capable of storing configurations for multiple instruments. For instance, if you have both a 300C, and a 305C, DMC can store the configurations and calibrations for both, and you can select which instrument you are using for a particular test. Clicking Add Instrument will add the selected instrument to the list with the default calibration factors.



NOTE: You should still perform a proper calibration of your dual-mode system or your length controller and force transducer, but for now the default values will work fine.

- 5) If you want to perform a calibration then scroll the list so that the instrument you wish to calibrate is at the top of the list. Click the calibrate button to the right of the instrument list. If you are using instruments that are not listed on the pull-down selector (i.e., you have selected "Other") then make sure you perform the calibration on them before proceeding to step 6.
- 6) Click on Setup > Channel Setup.
- 7) Using the pull-downs at the left set Length In, Length Out, Force In, and Force Out to the corresponding channels on your instrument. Choose appropriate units and set the precision according to your preferences. Good settings for a 300C are mm and mN, 3 digits of precision in length, 1 digit in force. Click Save Changes when done.
- 8) If you've selected reference units on the Channel Setup then you must enter a Reference Force (Fmax) and Reference Length (Lo) in the boxes provided on the main window. Fmax is only required for plots of F/Fmax therefore if Fmax is not known you can enter 1 for now. The Lo

value is used for plotting length in terms of L/Lo but it can also be used in the test protocols for setting length. Do not set the Reference Length or Reference Force to zero. If in doubt set them both to 1.

2.2.2 Creating a Protocol

DMC runs experiments by following a set of instructions called a Protocol. To begin an experiment, a protocol defining the experiment must be written. The following procedure demonstrates a simple protocol.

- 1) Click Protocol on the menu bar.
- 2) The protocol editor window (*Figure 2*) allows the user to create a series of events based on time. There are four headings on the screen labeled

Wait(s) Then (action) On (port) Parameters

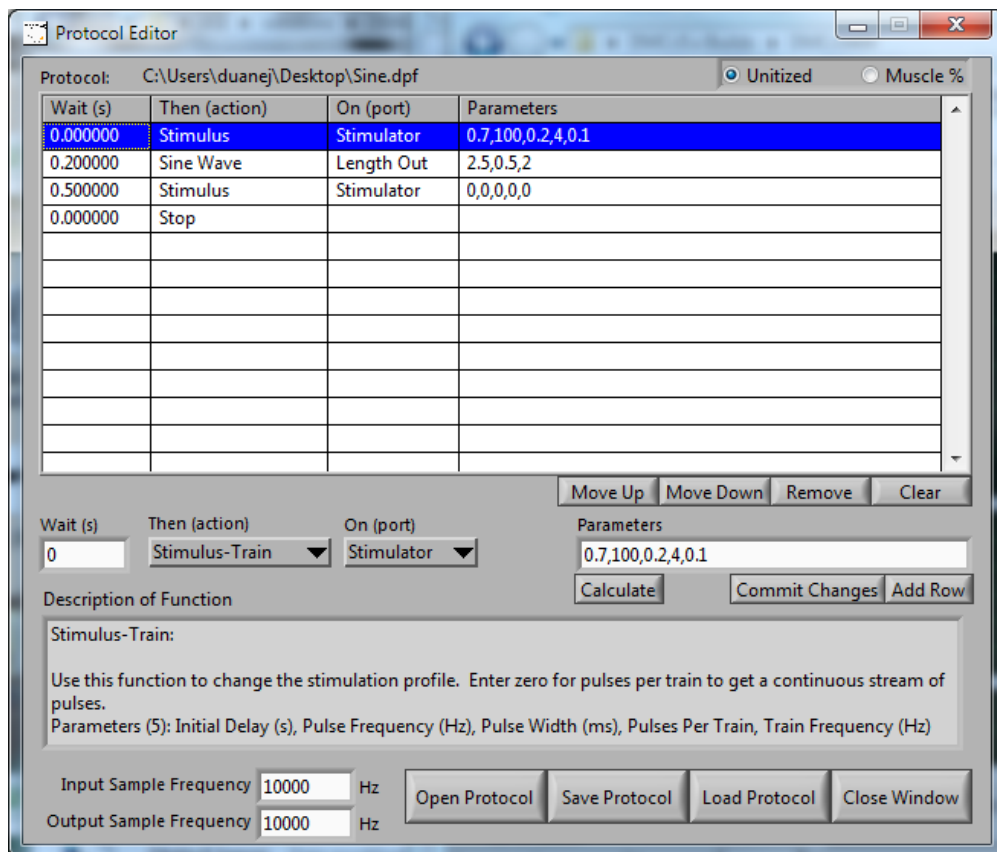


Figure 2: Protocol Editor Window

- 3) Control buttons and text entry boxes are located near the centre of the screen. Located at the bottom of the screen are text entry boxes to allow you to set the Input and Output Sampling Frequencies. To the right of the text entry boxes are four buttons labeled: Open Protocol, Save Protocol, Load Protocol, and Close Window.
- 4) For this example we will create a test protocol that will demonstrate length control, and electrical stimulus. The protocol will stimulate the muscle and perform a length sine

movement. Enter the protocol shown in *Figure 2* by entering the Wait (s), Then (action), On (port) and Parameters values in the central protocol edit section of the window. If the row doesn't exist then you can click Add Row first, enter the values and then click Commit Change or you can first enter the values and then simply click Add Row which will add the currently defined row and commit it in one step. Information about the current action is displayed in the box near the bottom of the screen labeled Description of Function. This text box provides a brief description of each function including the expected number of parameters, and what each parameter is.



NOTE: Protocol steps cannot overlap in time due to the nature of the protocol editor (you cannot cause a change in length and force at the same time), you can cause stimulation to occur during a length or force change. This is done by issuing the Stimulation command before the length/force command and including an initial delay value in the stimulation command. This delays the start of the stimulation by a set amount of time from when the command occurs in the protocol. Test protocols can be of any length and can contain multiple occurrences of the same function if desired.

- 5) Protocols must be saved before they can be loaded. Press the Save Protocol button, enter an appropriate file name and then press the Load Protocol button which will load the protocol into memory and generate the samples for output. The protocol is now ready to run.

More advanced experiments can be created by using a Sequence. Sequences are a series of Protocols which are automatically run sequentially. See Section 3.2.4 *Sequence Editor* for more information about this.

2.2.3 Running an Experiment

Before running an experiment, you may wish to start the Live Data Monitor. The Live Data Monitor provides a real-time scrolling output on a separate window that resembles an oscilloscope or a strip-chart recorder. It is very useful at providing a long-term record of what the input data channels are recording. The main screen provides a numerical output of the current Lin and Fin. This readout is useful to see what these values are at any given time but for slow trends (like monitoring resting tension) it is very useful to have the recording from the Live Data Monitor function. Click on File>Live Data to open the Live Data Monitor window. The Live Data Monitor runs independently of the main control and graphics section of the program and there is no concern that it will interfere with the main control program. The Live Data Monitor collects data at a constant 100 Hz. See Section 3.3 *Live Data Monitor* for a more detailed description.

Press the Start Test button on the bottom left side of the main screen to execute the protocol. The protocol will start as soon as you press the button and as soon as it is complete the results will be graphed on the main screen. For very short protocols the main plot appears so quickly that it seems to almost be plotting as the protocol progresses. However, for long protocols you may want to view the results of the protocol as it occurs. For this case use the Live Data Monitor to show test results as they are taken.

When the protocol is complete the data can be saved by clicking on File>Save Data. Alternatively, if the "Save on Test Completion" button is selected then a data save window will popup automatically at the conclusion of each test which will allow you to enter a data file name and location.

The Analysis button can be used to review the stored data, zoom in on a selected area and perform calculations. See Section 3.4 *Analysis* for more details on using Analysis.

3 General Operating Procedure

The 610A Dynamic Muscle Control program uses a familiar Windows-type interface that consists of a main window containing a graphics window, control buttons, several text readouts and a series of drop-down menus. The main window can be moved, re-sized, minimized, maximized and closed by clicking on the various window controls provided. In the upper right corner of the window are minimize and maximize buttons. Clicking anywhere on the window will bring the focus to the window. The window can be dynamically re-sized by clicking on a border or a corner of the window. Details of the main program window and program operation will be presented in the following sections.

3.1 Main Screen

The main screen consists of a menu bar at the top, a large graphics window located in the centre, a number of text readouts and control buttons, and a status line at the bottom of the window, see *Figure 3*.

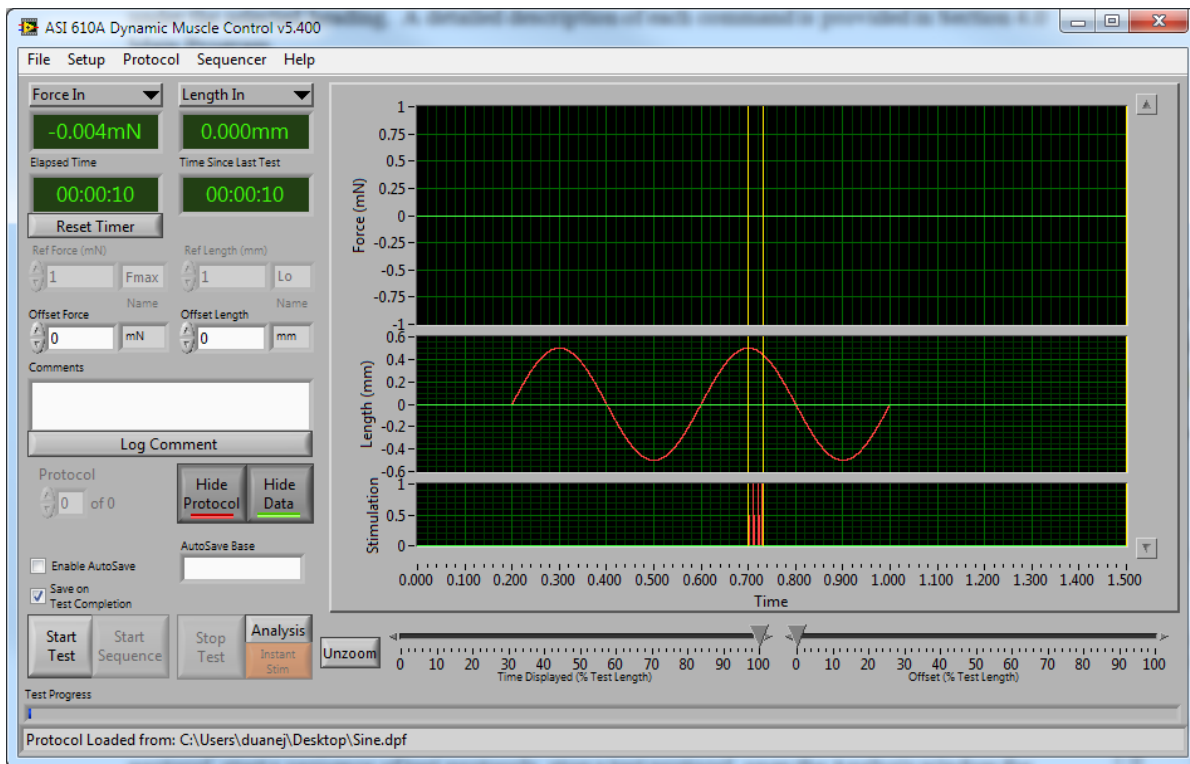


Figure 3: 610A DMC Main Window

3.1.1 Graphics Window

The graphics window is used to plot the length and force measured from the muscle tissue and to show stimulation. The graph consists of time along the x-axis, force on the upper graph, length on the centre graph, and stimulus on the lower graph. The input and output traces are plotted in different colours, red shows the protocol outputs and green shows the measured test data. Yellow cursors are placed on the graph to denote the starting and ending points of each stimulus command. This allows you to easily line up your stimulus with a change in length, or force. The stimulus signal is drawn as a solid red bar between the yellow cursors whenever the input data collection rate is less than 10 kHz. This bar shows the time interval when stimulus is occurring, the actual stimulation pattern is set by the protocol. When

the data collection rate is set to 10 kHz there is sufficient resolution to display each individual stimulus pulse and thus the red bar is replaced with the individual stimulus pulses.

The graphs are updated at the completion of each test protocol and also whenever the protocol is changed. The relative size of each of the graphs can be changed by dragging the horizontal grey bars between the graphs to resize them and in the event the graph is sized larger than the available area a vertical scroll bar will appear on the right side of the graphing area. The display units for length and force are set using Setup>Channel Setup. The data shown is set by clicking the Show/Hide Protocol or Show/Hide Data buttons. The time range of the data is controlled by using the sliders located below the graphs which is used to pan and zoom the window or you can use click-zoom by left clicking anywhere on the graph, dragging out a box and then releasing the mouse button, or by typing in the starting and ending times on the horizontal time axis (i.e., click on the 0.000 time label on the left of the time axis and type in a time, when you press enter the graph will automatically zoom to that time interval. You can cause repeated zooms by click-zoom or using the cursor controls. To return the data display to the entire test interval simply click the Unzoom button. The program automatically scales the vertical axes to the range of the collected data.

Further data analysis is provided through the Analysis button found near the bottom of the main window above the Instant Stim button. The Analysis button opens an Analysis window where further data manipulation and calculations can be performed; please refer to Section 3.4 *Analysis* for details. There are two companion programs to DMC that provide many standard muscle physiology analysis routines. These programs are Dynamic Muscle Analysis (DMA, model 611A) and DMA High-Throughput (model 612A). Please contact Aurora Scientific for further information about our analysis programs.

3.1.2 Control Buttons

The main screen includes ten control buttons. These are: Reset Timer, Log Comment, Show/Hide Protocol, Show/Hide Data, Start Test, Start Sequence, Stop Test, Analysis, Instant Stim and Unzoom (see *Figure 3*).

3.1.2.1 Reset Timer Button

The Reset Timer button is used to reset the Elapsed Time displayed directly above the button. The timer displays elapsed time since the program was started, or since the last time you clicked the Reset Timer button. This timer can be used to time the start of your protocols in relation to other experimental information.

3.1.2.2 Log Comment Button

The Log Comment button is used to place the contents of the Comments box into the log file. DMC creates a unique log file each day that the program is started, and records information such as the time a protocol is started, what files are created, when protocols were loaded, etc. in this file. The Log Comment button allows the user to enter their own comments into this file to better annotate the specifics of a given experiment. All comments are time stamped with the time when you pressed the Log Comment button.

3.1.2.3 Show/Hide Protocol Button

This button turns the display of the protocol (shown in red) on or off on each of the graphs. The protocol values are Lout, Fout and Stim out. Since each plot automatically scales the vertical axis, turning off the protocol data often allows the test data to be viewed more clearly.

3.1.2.4 *Show/Hide Data Button*

This button turns the display of the test data (shown in green) on or off on each of the graphs. The test data values are Lin, Fin and Stim out. Each plot is automatically scaled to the range of the displayed data. In some cases it helps to turn off the test data if there is a need to observe the protocol.

3.1.2.5 *Start Test Button*

The Start Test button is used to start a test protocol. A protocol must exist (saved) and be loaded into memory (by the Load Protocol button in the protocol editor) before the Start Test button will operate. Upon clicking the Start Test button the program will sequence through the test protocol, performing the functions listed there. Immediately following completion of the test the length and force results will be plotted on the graphics window. If the Save on Test Completion checkbox is checked then the data will be automatically saved to a location specified.

3.1.2.6 *Start Sequence Button*

The Start Sequence button is used to start a sequence of test protocols. A sequence must exist and be loaded into memory from the Load Sequence button in the Sequence Editor window before the Start Sequence button will operate. Upon clicking the Start Sequence button the program will execute the first protocol then wait for the Next Test button to be pushed, or, if automatic timing is set, it will automatically advance to the next protocol after the defined time. Immediately following completion of each protocol in the sequence the length and force results will be plotted on the graphics window.

3.1.2.7 *Next Test Button*

The Next Test button is used to start the next protocol in a sequence. The Next Test protocol will only become active after the Start Sequence button has been pressed and then only if the chosen sequence contains more than two protocols and the next protocol in the sequence is set to a manually timed step. The status line will indicate that it is waiting for the user to click Next Test to continue.

3.1.2.8 *Stop Test Button*

The Stop Test button is used to stop a test protocol or a sequence of test protocols. The button freezes all control action of the program as soon as the button is pressed. For example, if the length out is set to 1.5 mm when the Stop Test button is pressed then it will stay at this value. The graph presented on the main screen will show actual Length and Force signals up to the point at which the Stop Test button was pressed. Think of this control as an emergency stop. If something goes wrong during your protocol or sequence, this button will stop all control actions including length, force and stimulation control.

3.1.2.9 *Analysis Button*

The Analysis button is used to open the analysis window. This window is used to examine the recorded data in greater detail, and perform simple analysis on it. More information is listed in Section 3.4 *Analysis*. For more in-depth analysis, please use the Dynamic Muscle Analysis software.

3.1.2.10 *Instant Stim Button*

The Instant Stim button is used to control a stimulator when not running a protocol. This is useful when setting up your electrodes, to perhaps find the location with the best response. To activate stimulation you must first set up the stim parameters you require using the Setup > Instant Stim menu. After starting

Instant Stim the button changes to a red Stop button to allow you to abort a string of stimulation pulses. The button is orange to remind you that this action can produce dangerous voltages at the stimulator output, and that you must use caution to ensure your safety.

3.1.2.11 Unzoom Button

The Unzoom button is used to return the pan and zoom sliders to their default position to view the entire data file.

3.1.3 Text Readout Boxes

Ten text boxes are located on the main screen. Four of these provide text readout and the other six are for text entry.

The top two boxes, shown as green numbers, provide the current values of the selected data input channels (you can define either box to show Force In, Length In, Aux1 – Aux 6). Normally these readouts will be set to monitor Force In and Length In. Below these readouts are two timers showing Elapsed Time and Time Since Last Test.

The next group of readouts includes the reference force and length (Ref Force and Ref Length) and the Offset Force and Offset Length. The reference values can only be entered if the units are set to reference using Setup>Channel Setup. The offset values are used to set the initial values of force and length at the start of a test.

The comments box provides a simple method of adding user comments to your data files and to the daily log file kept by the program. Text entered in the Comments box will automatically be saved into all data files when each test completes. Beneath the Comments box is a button labeled Log Comment, clicking this button will add the currently displayed text in the Comments box to the daily log file along with a time stamp.

Near the bottom of the window is the Autosave Base text entry box. This box allows the user to set the base filename used when the program automatically saves data. When the Enable AutoSave checkbox is checked data files are automatically saved at the end of a test without the user being prompted for a file name. To use the Autosave feature first set the folder where the data files will be stored by using the Setup>AutoSave Folder menu option. Then set the base filename by entering it in the AutoSave Base text entry box. Each automatically saved data file will be saved into the specified folder with the base filename and a sequential number.

3.1.4 Test Progress and Status Line

A test progress bar is provided at the bottom of the window which changes to a green line as the test progresses. Below the progress bar is a status line that provides information about program operation.

3.2 Main Menu

The main menu consists of the following five headings.

File Setup Protocol Sequencer Help

3.2.1 File Menu

The File menu contains commands to save data files, open the Live Data Monitor, open the Log File folder, and exit the program.

3.2.1.1 *Save Current Data*

This menu item opens a Save As dialog box that allows the current data to be saved to disk. Note: the data file is stored in ASCII format and the structure of the file is provided in Appendix A.

3.2.1.2 *Live Data Monitor*

This menu item opens the Live Data Monitor window; see Section 3.3 *Live Data Monitor* for more details.

3.2.1.3 *Open Log Folder*

This menu item uses Windows Explorer to open the folder where log files are stored.

3.2.1.4 *Exit*

This menu item closes the 610A DMC program.

3.2.2 Setup Menu

The Setup menu contains commands to manage and calibrate your instruments, set up the channel configuration and display units, set up Instant Stim, and Autosave features, and to enable or disable external triggers.

3.2.2.1 *My Instruments*

The My Instruments menu item found under the Setup menu allows the user to setup and calibrate their instruments. The My Instruments window, see *Figure 4*, is used to tell DMC what instruments you have, and what their calibration factors are. Users can input as many instruments as they like, including all instruments made by Aurora Scientific, as well as any 3rd party instruments with an analog output. My Instruments includes the factory settings for the calibration factors for all ASI instruments however 3rd party instruments will need to be calibrated before their calibration factors can be shown. As noted at the bottom of the My Instruments window, Channel Setup must be complete before calibrating your instruments. The Channel Setup window is covered later in this manual in Section 3.2.2.2 *Channel Setup*.

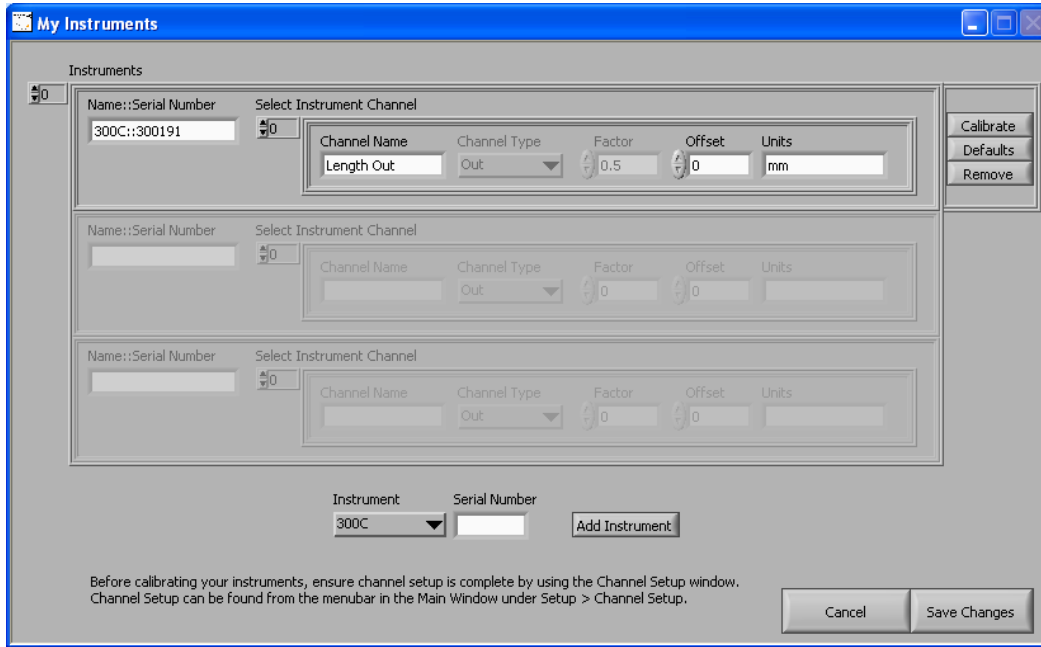


Figure 4: My Instruments Window

To add a new instrument to the list, simply select the desired model from the drop-down at the bottom of the window, enter the instrument’s serial number (located on the foil serial number tag on the back or side of the instrument), and click the Add Instrument button. The instrument will be added to the list with its nominal conversion factors. These nominal conversion factors are good enough for relative measurements, but for precise absolute measurement, your instruments must be calibrated.

To calibrate your instrument, scroll the desired instrument to the top of the list using the Up/Down arrow control found at the top left of the window, and then click the button labeled Calibrate. This will open the Calibration Editor window, which is discussed in detail later in this manual in Section 4.1 *Calibration Editor*.

To revert your instrument to the nominal defaults, scroll the instrument to the top of the list using the Up/Down arrow control found at the top left of the window, and then click the button labeled Defaults.

To remove an instrument from the list, scroll the instrument to the top of the list using the Up/Down arrow control found at the top left of the window, and then click the button labeled Remove.

3.2.2.2 Channel Setup

The channel setup window is used to configure the input channels for each individual instrument connected to the PC. This configuration involves selecting the instrument/channel from My Instruments that is connected to each of the physical channels on the 604A Signal Interface.

Upon opening this window (Figure 5), the controls are populated with the instruments currently stored in My Instruments. The calibration constants for the selected device and channel will automatically populate when you select a connected device, using the leftmost drop down controls.

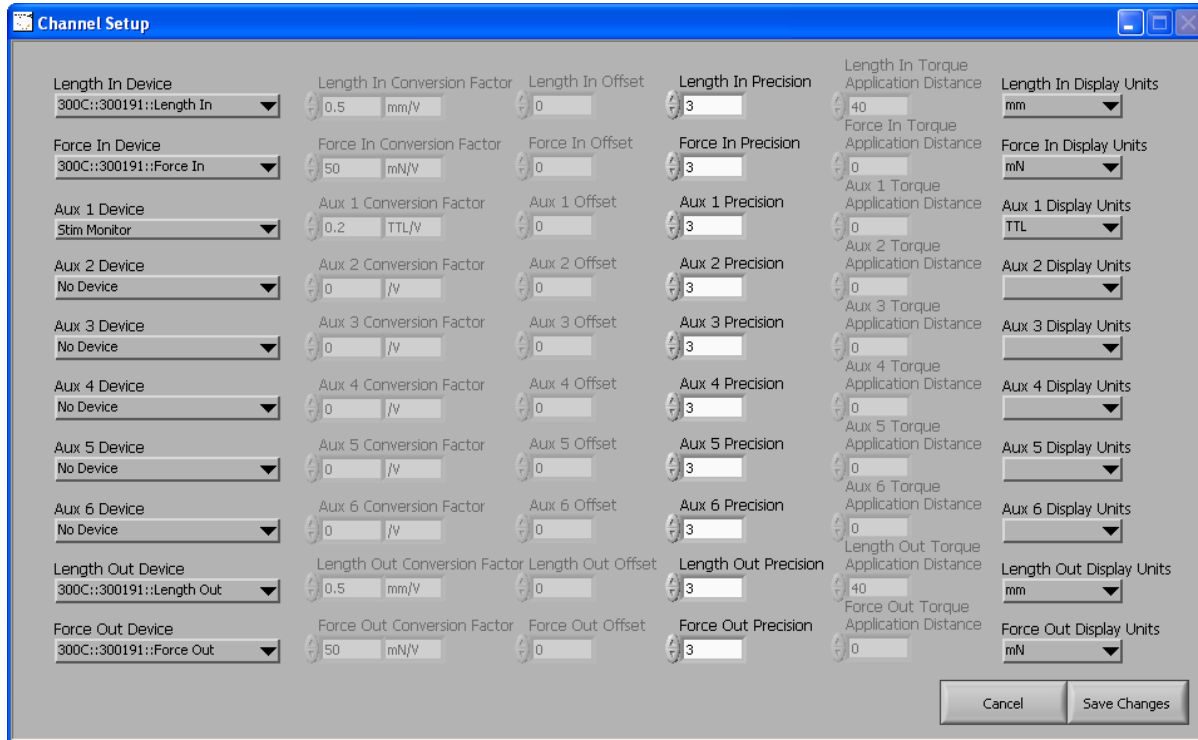



Figure 5: Channel Setup Window

The option 'Stim Monitor' is typically used on channel Aux 1 to monitor the stimulator output from DMC. This is done by connecting a BNC T to the Stimulator Output, and running a BNC cable from there to Aux 1, and from the T to the stimulator. This allows DMC to record the actual stimulation pulses that went out. Alternatively you can connect the Sync Out from a 701C stimulator to Aux 1.

For devices that measure in base units of either mm, or mN, DMC will allow you to display the data in several different units (e.g., μm , cm, N, g). For devices that measure in other units, such as $^{\circ}\text{C}$, DMC will ONLY allow you to display in terms of the base unit.

DMC also offers torque and angle units for displaying the data from the sensors, but you must provide DMC with the appropriate Torque Application Distance. This is the distance from the point of torque application, to the centre of the motor shaft. The program knows the default Torque Application Distances for all Aurora Scientific 300C series instruments and will automatically populated these fields when selecting torque and angle units. The user can overwrite these if they are using modified Aurora Scientific lever arms.

Additionally, DMC allows you to display data in terms of Reference units, such as Lo and Fmax. To do this, change the display unit to Ref, and click Save Changes. Then, on the main panel of DMC, enter the reference length and reference force, in terms of mm or mN.

 *NOTE: If you wish to control outputs in terms of reference units, you MUST re-load the protocol any time you make a change to the reference length or force. This is because DMC generates the entire protocol when you load it, and when you change the reference values the program must regenerate the protocol with the new values.*

The DISPLAY units of Length Out and Force Out are the units that the protocol is calculated with. You must choose the same units for Length In/Length Out, and Force In/Force Out in order to ensure proper display of the graphs. The program enforces this by automatically changing the linked unit when you change the display units for one of the paired channels.

3.2.2.3 Setup Instant Stim

The Setup Instant Stim window (see Figure 6) is used to set up the Instant Stim feature. The parameters are essentially the same as those in the protocol editor, and describe the pulse train that will come out. The settings shown in Figure 6 will result in a single 0.5ms pulse. You can change these settings to match any stimulation parameters you require, including longer pulses, shorter pulses (pulse width must be between 0.1 and 10.0 ms), multiple pulses, pulse trains or a single burst of pulses. A warning is displayed if the values entered are invalid. Once the parameters are set using this menu, the Instant Stim button on the front panel becomes active.

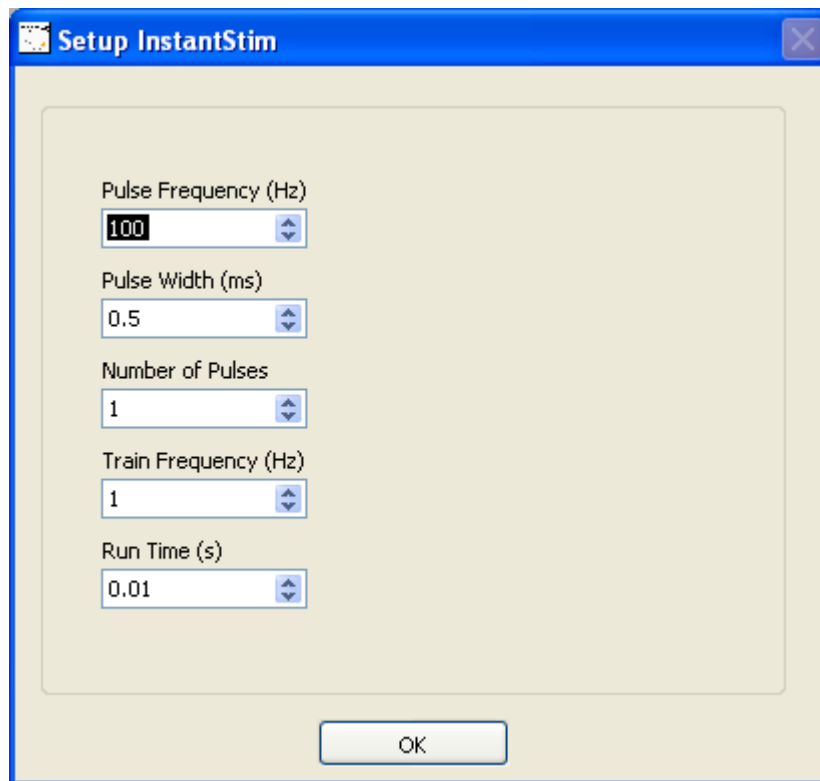


Figure 6: Instant Stim Setup

3.2.2.4 Enable Input Triggers

This menu option Enables/Disables the external Start Test and Start Sequence triggers. You can use a TTL signal from an outside instrument to trigger DMC to start a protocol or to start a sequence. The ports labeled “Trg In 1” and “Trg In 2” on the 604A signal interface are used as the input triggers for Start Test and Start Sequence respectively.

3.2.2.5 AutoSave Folder

This menu option brings up a Save As window. Navigate to the folder you wish to auto-save into, and then click on the Current Folder button. Once you have selected a folder to store data files in then you can check the Enable AutoSave checkbox on the main window.

3.2.3 Protocol Editor

Clicking on the Protocol menu option brings up the Protocol Editor window. Using the Protocol Editor, a user can create, edit, and load protocols into the software. In addition, navigating through the Windows file system to the location of a saved protocol will allow the user to start DMC by clicking on the protocol file. DMC will be loaded and prepare the protocol for run, much like you can open Microsoft Word by clicking on a Word document.

Test protocols are the heart of the control system and they provide all the functions necessary to generate any muscle physiology test desired. The Protocol Editor screen can be divided into the following four sections: a) the top portion of the screen displays the test protocol, b) the middle section allows the user to edit selected lines of the protocol, c) a text section is below the editing section and it displays information about the selected function and, d) at the bottom the Sampling Rates are set and control buttons are provided.

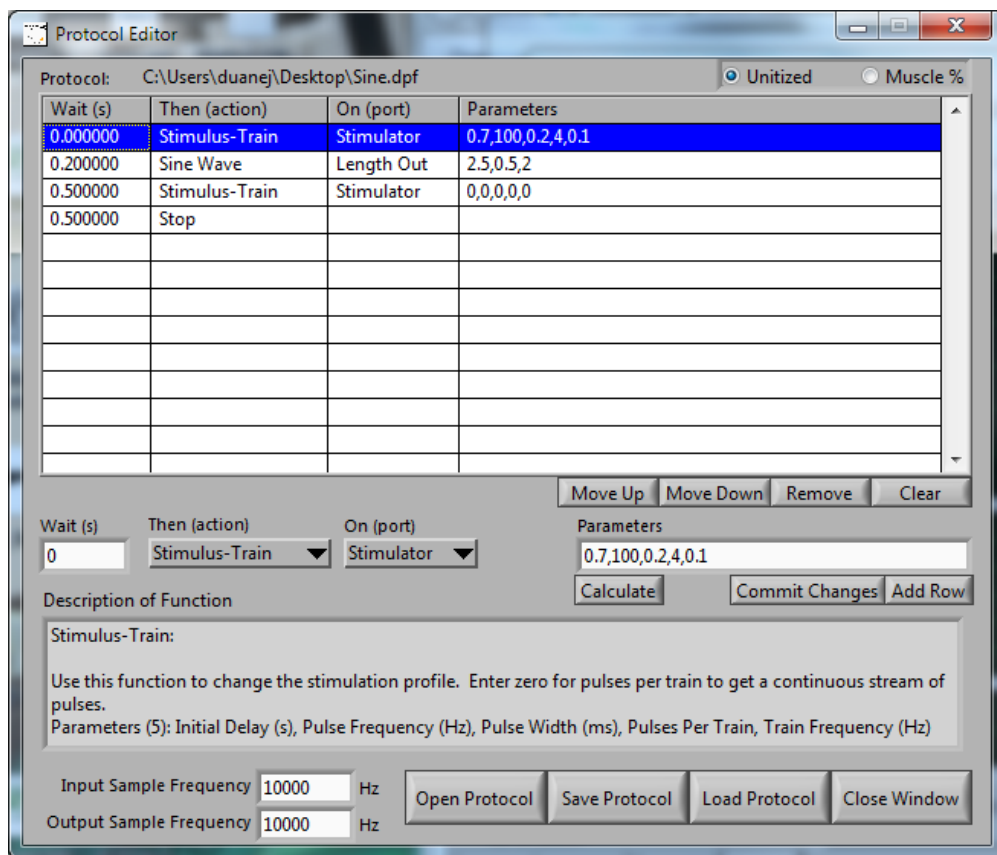


Figure 7: Protocol Editor

All test protocols are listed in order of steps. Each step includes a Wait time, a function and its port and function parameters. A step cannot start before a previous step has completed. Length, Force, and Trigger steps must complete before another Length or Force step can start. Stimulus functions can be delayed so that they happen after the start of the next step.

3.2.3.1 Protocol Functions

The following section lists all available functions including a brief description, a list of the required parameters for the function and an example of the function's usage. The examples are all shown as a wait time followed by the function name, channel, and parameters.

Step

Description: Perform a step change in the output channel selected to the specified value.
 Parameters (1): value to step to (channel display units)
 e.g.: 0.5 Step Length Out 1

Ramp

Description: Perform a ramp change in the output channel selected to the specified value, over a specified time.
 Parameters (2): value to ramp to (channel display units), Time (s)
 e.g.: 0.5 Ramp Length Out 1.0,2.5

Sine Wave

Description: Generate a sine wave on the selected output port.
 Parameters (3): Frequency (Hz), Amplitude (channel display units), Number of Cycles
 e.g.: 0.5 Sine Wave Length Out 100,5,0,2

Sum-Sine Wave

Description: Generate a waveform which is the sum of 2 sine waves on the selected port.
 Parameters (5): Frequency 1 (Hz), Amplitude 1 (channel display units), Frequency 2 (Hz), Amplitude 2 (channel display units), Time (s)
 e.g.: 0.5 Sum-Sine Wave Length Out 100,5,10,0,5,2.5

Stimulus-Train

Description: Issues a train stimulation profile.
 Parameters (5): Initial Delay (s), Pulse Frequency (Hz), Pulse Width (ms), Pulses Per Train, Train Frequency (Hz) Note: Entering zero (0) for pulses per train results in a continuous stream of pulses.
 e.g.: 0.5 Stimulus-Train Stimulator 0.7,100,0,2,5,1

Stimulus-Tetanus

Description: Issues a tetanus stimulation profile.
 Parameters (4): Initial Delay (s), Pulse Frequency (Hz), Pulse Width (ms), Duration (s)
 e.g.: 0.5 Stimulus-Tetanus Stimulator 0.7,100,0.2,1

Stimulus-Twitch

Description: Issues a twitch stimulation profile.
 Parameters (2): Initial Delay (s), Pulse Width (ms)
 e.g.: 0.5 Stimulus-Twitch Stimulator 0.7,0.2

Trigger

Description: Issues an output trigger.
 Parameters (1): Trigger setting
 Trigger Setting Values: 0 = All Off, 1 = Trig Out 1 on, 2 = Trig Out 2 on, 3 = Both on, 4 = 604B Switch
 e.g.: 0.5 Trigger Length Out 3

Stop

Description: Use this function at the end of a protocol to allow data collection to continue for the wait time associated with the Stop function.
 Parameters (0): None.
 e.g.: 0.5 Stop

A Note about Stimulus Functions

Stimulus functions are special because they include a delay time. The delay time is included to allow a stimulus to start after the start of a length or force command. Since a step cannot start before the end of a previous step and because stimulation usually starts during a length or force function we have included the delay time to get around this limitation. Normally the user would specify the stimulus function and set the delay time so that the stimulus occurred during the following function. Three stimulus functions exist to make it easier for the user to define the profile required. These functions are: Stimulus-Train, Stimulus-Tetanus and Stimulus-Twitch.

The Stimulus functions use between 2 and 5 parameters to specify the function. The parameters for Stimulus-Train are: Initial Delay, Pulse Frequency, Pulse Width, Pulses per Train, and Train Frequency. The parameters for Stimulus-Tetanus are: Initial Delay, Pulse Frequency, Pulse Width and Duration. The parameters for Stimulus-Twitch are: Initial Delay and Pulse Width.

Initial Delay is the length of time between the command being issued, and the first stimulus pulse. Use this to precisely control the placement of your stimulus in the commands to follow.

Pulse Frequency is the rate at which the individual pulses occur. This parameter sets the start of each individual pulse (in the example Pulse Frequency is set to 100 Hz or one pulse every 10 ms).

Pulse Width is the width of each individual stimulation pulse. In our example each pulse is 0.2 ms wide.

Duration is the length of time (s) that a Stimulus-Tetanus will be active for.

Pulses per Train is the number of pulses in each burst of pulses. If you are pacing cardiac tissue, then you would use this to set the number of pulses in each group. If you do not require periodic bursts of pulses then use Stimulus-Tetanus or Stimulus-Twitch.

Train Frequency is the rate at which the pulse trains get repeated. In the example Train Frequency is set to 0.1 Hz or a train starting every 10 s. If you wish to only receive a single group of pulses, then set this value to a sufficiently low number that the first repeat would happen AFTER the end of your test or use either the Stimulus-Tetanus or Stimulus-Twitch function.

3.2.3.2 Example Protocol

As an example we will create a test protocol that will demonstrate length control and electrical stimulus. The protocol will stimulate the muscle, perform a length sine movement, and continue to record data until the Stop command is processed. The protocol is shown in *Figure 7*.

Note the help text that is displayed in the box near the bottom of the screen. This text box provides a brief description of each function including the expected number of parameters, and what each parameter is. A very important note about protocols is that while steps cannot overlap in time due to the nature of the protocol editor (you cannot cause a change in length and force at the same time), you can cause stimulation to occur during a length change. This is done by setting an initial delay time in the Stimulation command. This delays the start of the stimulation by a set amount of time from when the command occurs in the protocol. Test protocols can be of any length and can contain multiple occurrences of the same function if desired.

3.2.3.3 Using the Protocol Editor

When editing or creating a protocol the step in the table is not updated until the user clicks on the parameter box and then clicks the Commit Changes button. If you are satisfied with the protocol and there are no errors press Save Protocol to save the protocol to disk. Please note that a protocol MUST be saved before it can be loaded and run. If you press the Close Window button before saving the protocol then all changes will be lost.

3.2.3.4 Controls

3.2.3.4.1 Sampling Frequency Control

The protocol editor includes two controls to set the sampling frequency for data collection. The Input Sample Frequency sets the data collection rate while the Output Sample Frequency sets the rate at which commands are sent to the instrument. If you are noticing that your data looks like a staircase, instead of a smooth curve, then use a higher input and output sampling frequencies. The accepted range for both input and output is from 100 Hz to 10 kHz.

3.2.3.4.2 Open Protocol Button

This button opens a previously saved protocol file for editing.

3.2.3.4.3 Save Protocol Button

This button saves a protocol file. The file is stored in ASCII format and the file structure is provided in *Appendix B – 610A Protocol File Structure*

3.2.3.4.4 Load Protocol Button

This button loads a protocol file into memory and generates the output control data. This must occur before a test can be run.

3.2.3.4.5 Unitized/Muscle %

This radio button is located on the upper right side of the window and it controls whether the protocol is unitized (uses units specified in Setup>Channel Setup), or is in terms of Muscle % (reference units expressed as percentages of Lo and Fmax).

3.2.4 Sequence Editor

The Sequencer button on the menu opens the Sequence Editor. The Sequence Editor allows the user to create and edit sequences which are a collection of protocols. The Sequence Editor looks and feels very much like the protocol editor. It also works in much the same way.

The Sequence Editor window can be divided into the following three sections: a) the top portion of the screen displays the table describing the sequence, b) the middle section allows the user to enter a base file name, select protocols and their corresponding file markers, and set that protocols parameters in a sequence, and c) four control buttons are provided below the editing section.

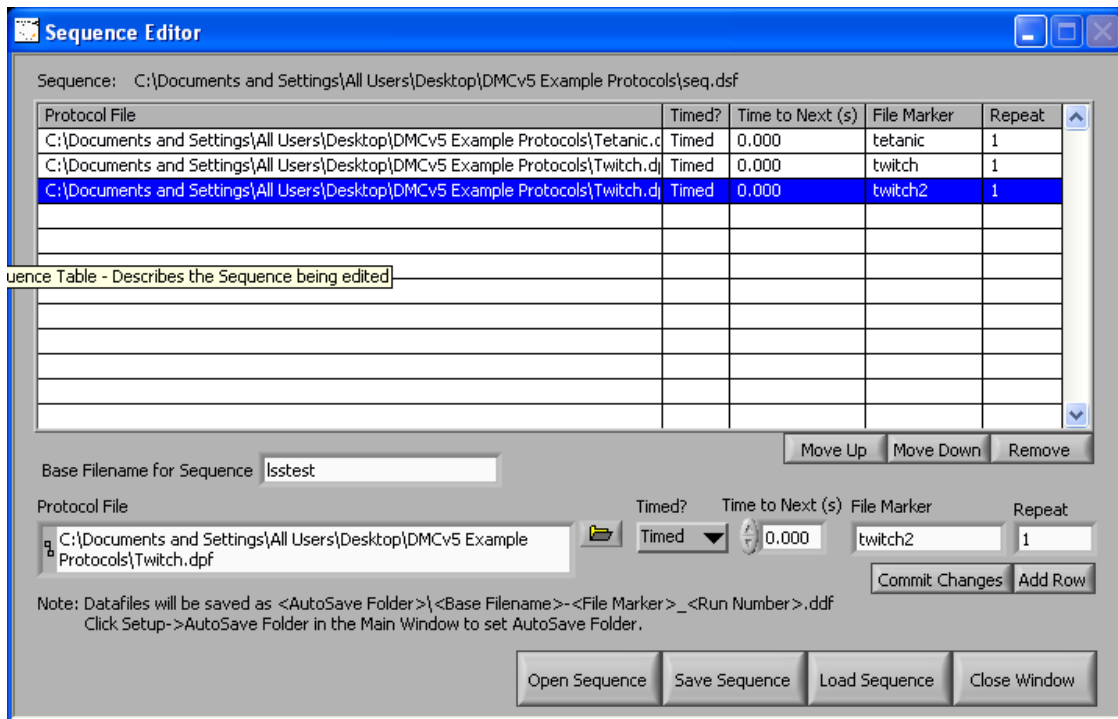


Figure 8: Sequence Editor Window

3.2.4.1 Example Sequence

Figure 8 provides a sample sequence consisting of a tetanic and two twitch protocols that run one after another.

The first step is to enter the names of the protocols to be included in the sequence. Protocol file names can be typed into the box provided or the Browse button can be used to open a file dialog window. It is more convenient to simply press the Browse button; highlight the desired protocol and press OK to select the protocol and automatically enter it in the sequence line (see Figure 11 for an example of protocol file selection using the Browse button.)

The Data File Name that will be used for storing the data from each protocol in the sequence is created from several parts. Most of these parts are user-configurable. The first portion, the file path, is set using the AutoSave Folder. This is set in the Setup menu on the main window of DMC. The next part of the file name is the Base Filename. This is set on a per-sequence basis, using the Base Filename control in the middle of the Sequence Editor. After this comes the File Marker section. This is set on a per-protocol basis. Each protocol in the sequence must have a unique File Marker. The final section of the data file names comes from the run number. Each time you run the sequence, this number will increment.

An unlimited number of protocols can be defined in a sequence. A sequence can also repeat a given protocol as many times as required. An example of this would be an experiment that used a pre-conditioning protocol followed by a test protocol and then followed by the same pre-conditioning protocol again, etc. Ensure that you use unique file markers for each instance of the pre-conditioning protocol.

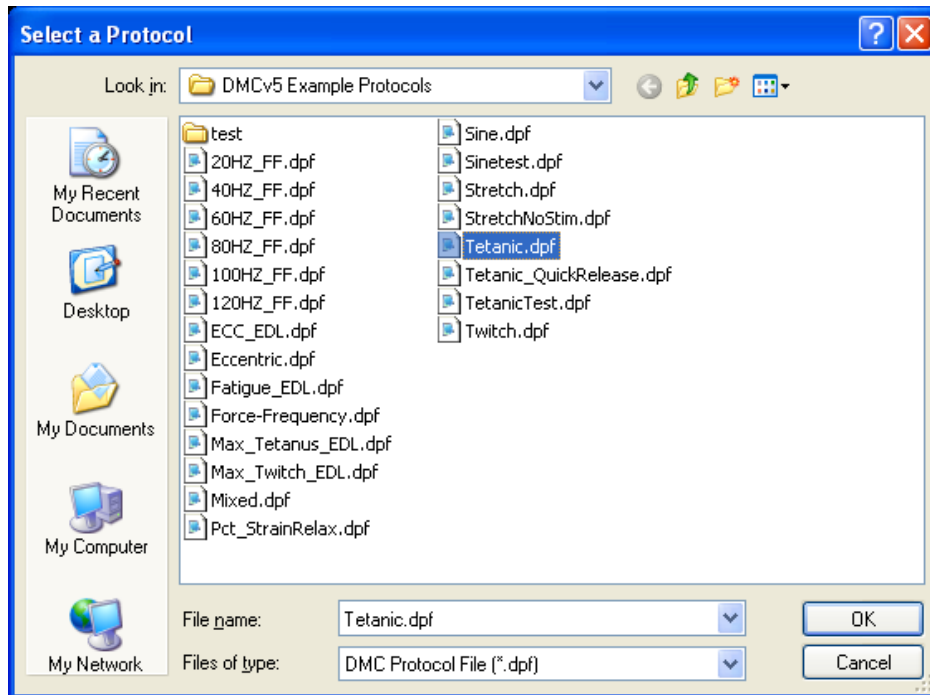


Figure 9: Select Protocol File Window

Once you are satisfied with the sequence you must save the sequence using the Save Sequence button.

3.2.4.2 Controls

3.2.4.2.1 Open Sequence

Opens a previously saved sequence file

3.2.4.2.2 Save Sequence

Saves a sequence file. The file is stored in ASCII format and the file structure is provided in *Appendix C – 610A Sequencer File Structure*

3.2.4.2.3 Load Sequence

Loads a sequence into memory. As we are not using a real-time operating system, we must pre-generate the output data streams before we can run a test. Clicking Load Sequence will enable the Start Sequence button on the Main Window.

3.2.5 Help Menu

The Help menu contains two commands: Topics, and About.

3.2.5.1 Topics

Opens the 610A DMC Help File.

3.2.5.2 About

Provides information about the 610A DMC program including contact information for Aurora Scientific and the program's version number.

3.3 Live Data Monitor

The Live Data Monitor provides a real-time output of length and force in a separate window. A data buffer is provided that allows the user to review the Length and Force inputs over the past 30 minutes. However Live Data Monitor can only show data for times when the window was open, if the window is closed then no data is buffered for display in the window.

Live Data Monitor includes controls to set the scale of the graph, the time base, and controls to freeze the display and scroll the display back and forth in time. Data is always sampled at 100 Hz so trends that take place over time show very well. However, because of the low sampling rate, short duration events are not displayed correctly. The window also includes another set of Start Test, Start Sequence, and Instant Stim buttons, to provide the flexibility to control tests from the Live Data Monitor window.

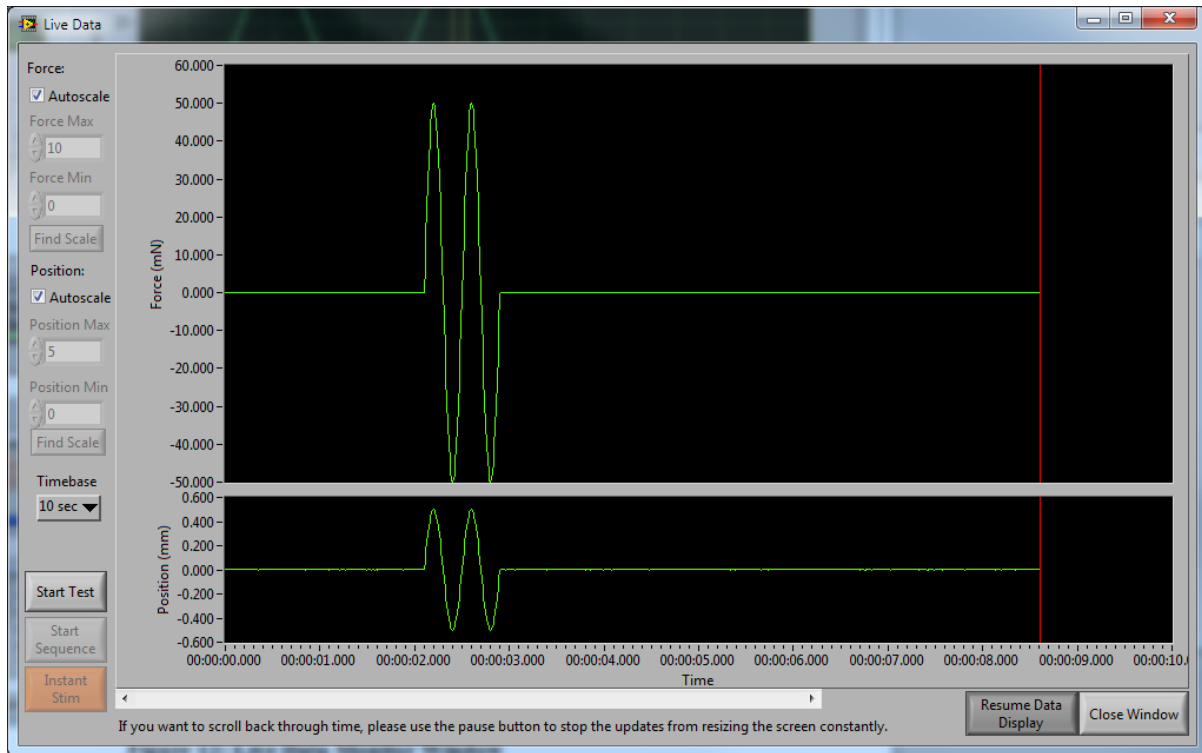


Figure 10: Live Data Monitor Window

3.3.1 Using Live Data Monitor

To use the Live Data Monitor, open it from the File menu as described in Section 3.2.1 *File Menu*.

The Live Data Monitor window will open and data will start to be shown on the screen.

Select an option from the Time Base drop down to choose the amount of data shown on the screen. The time base can vary from 10s to 30 min.

The Autoscale checkboxes can be used to enable/disable auto scaling of the displayed data. Disabling Autoscale allows you to set the vertical limits of the length and force graphs manually.

Use the Pause Data Display button to pause the scrolling of data. Once the display is paused you can then use the left or right arrow buttons to scroll through all data measured in the past 30 minutes.

3.3.1.1 Controls

3.3.1.1.1 Start Test

Begins the currently loaded protocol. This button behaves identically to the Start Test button on the Main Window. See Section 3.1.2.5 *Start Test Button* for details.

3.3.1.1.2 Start Sequence

Begins the currently loaded sequence of protocols. This button behaves identically to the Start Sequence button on the Main Window. See Section 3.1.2.6 *Start Sequence Button* for details.

3.3.1.1.3 *Instant Stim*

Sends the stimulus profile currently set in the Instant Stim Window. This button performs identically to the Instant Stim button on the Main Window. See Section 3.1.2.10 *Instant Stim Button* for details.

3.3.1.1.4 *Close Window*

Closes the Live Data Monitor Window

3.3.1.1.5 *Pause/Resume Data Display*

This button pauses and resumes the update of the Live Data graph. When the Live Data Monitor is paused the scroll bar can then be used to review previous data. Data continues to be recorded in the background even when the display is paused. When the Resume Data Display button is pressed the display will update to show the most recent data.

3.3.1.1.6 *Timebase*

Data is graphed for a set span of time set by the Timebase drop down menu. Older data is viewable by clicking Pause Data Display and using the scroll bar at the bottom to scroll through previous data.

3.3.1.1.7 *Scale Controls*

Each channel can be scaled individually by setting the Min and Max settings. Min is the value on the y-axis at the bottom of the screen, max is the value at the top. All data is plotted on this scale. Scale Controls can only be used if Autoscale is unchecked.

3.3.1.1.8 *Autoscale*

The Autoscale checkbox controls whether the auto scaling function is active or not. Two Autoscale controls are provided, one for the Force display and the other for the Position display. This function automatically sets the minimum and maximum values on the graph to optimize the display of all the data in the current Timebase shown. The scaling changes dynamically as new data is plotted and old data is pushed off the graph.

3.3.1.1.9 *Find Scale*

Automatically updates the Min/Max values to optimize the display of all the data in the current Timebase. This will not dynamically update like Autoscale does. Find Scale can only be used if Autoscale is unchecked.

3.4 Analysis

The analysis section of the program provides a limited set of analysis, graphics and storage functions. A far more exhaustive analysis capability is provided with our Dynamic Muscle Analysis (DMA) program and its companion program DMA High-Throughput (DMA-HT) which provides high speed, automatic data analysis.

Open the Analysis window by clicking the Analysis menu item in the menu bar at the top of the main screen. The Analysis window will appear as in Figure 11 and includes controls to turn on/off data and protocol plotting and to set the time base of interest. A number of text boxes are provided at the bottom of the window which shows maximum and minimum force and length along with time to these maxima and minima. A pull-down menu is provided at the top of the window that is used to select the data to be displayed. In the case of data output from a sequence this control allows you to look back through all the protocols that were executed during the sequence. All of these controls are discussed in detail in the following sections.

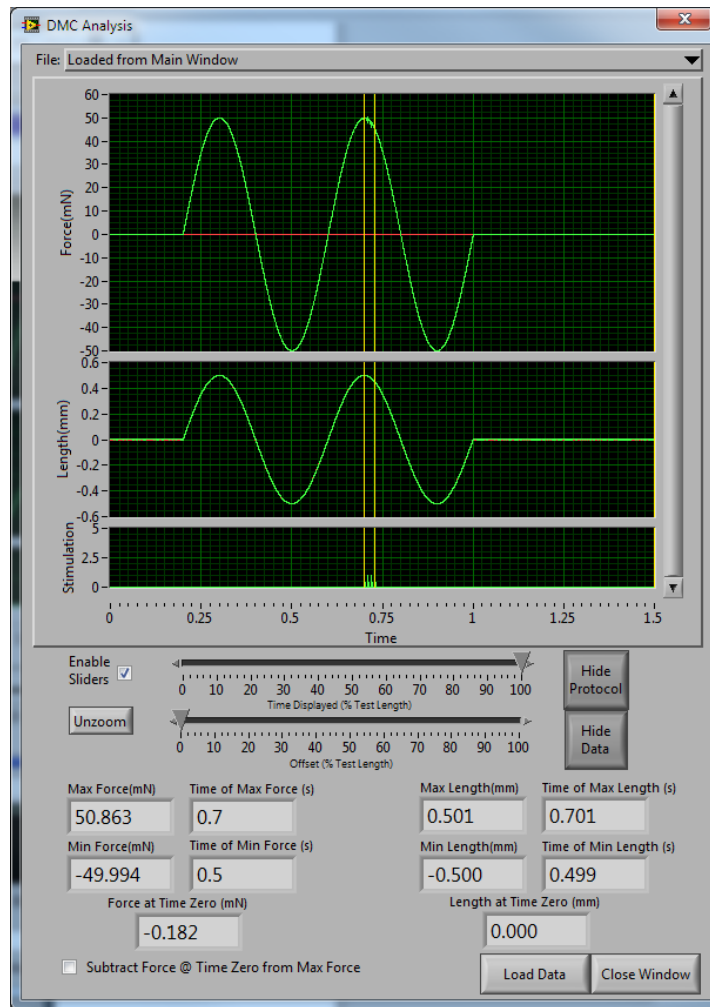


Figure 11: Analysis Window

3.4.1 Using the Analysis Window

The Analysis window is primarily a data display window. Directly beneath the graphics area are a series of controls that adjust settings on the Analysis window.

3.4.1.1 Controls

3.4.1.1.1 Enable Sliders Checkbox

This checkbox turns the sliders on or off. When the sliders are off, the graph displays the whole test, and when the sliders are turned on, the graph displays the selected portion of the test.

3.4.1.1.2 Unzoom Button

This button will reset the sliders back to viewing the whole test. This allows the user to quickly reset the plotted time scale.

3.4.1.1.3 Time Displayed Slider

This slider controls, as a percentage of the entire test, how much data is displayed on the screen. Click on the inverted triangle shown on the slider and drag it to the left or right to control the time displayed.

3.4.1.1.4 Offset Slider

This slider controls, as a percentage of the entire test, the starting time shown at the left side of the graphics screen. Click on the inverted triangle shown on the slider and drag it to the left or right to control the start time of the displayed data.

3.4.1.1.5 Click Zoom

A click zoom function is included with Analysis. Simply left click on the graph, drag out a box the size of the desired zoom and release the mouse button. The graph will automatically zoom to the time interval outlined by the click zoom box.

3.4.1.1.6 Show/Hide Protocol Button

This button turns the display of the protocol (shown in red) on or off on each of the graphs. The protocol values are Lout, Fout and Stim out. Since each plot automatically scales the vertical axis, turning off the protocol data often allows the test data to be viewed more clearly.

3.4.1.1.7 Show/Hide Data Button

This button turns the display of the test data (shown in green) on or off on each of the graphs. The test data values are Lin, Fin and Stim out. Each plot is automatically scaled to the range of the displayed data. In some cases it helps to turn off the test data if there is a need to observe the protocol data.

3.4.1.1.8 File Pull Down

The File Pull-down is located at the top of the window and it provides a pull-down list of the files included in a test sequence. Any file in the protocol can be selected and then viewed.

3.4.1.1.9 Load Data Button

The Load Data button is located at the bottom of the window and it opens a file dialog window which allows a data file to be loaded and analyzed.

3.4.1.1.10 Close Window

The Close Window button is located at the bottom of the window and closes the Analysis window.

4 Calibration, and Software Maintenance

4.1 Calibration Editor

The Calibration Editor is used to calibrate instruments. There are three forms of the calibration editor that are used for calibrating length in, force in and force out. It is accessed from the My Instruments window as described in Section 3.2.2.1 *My Instruments*.

4.1.1 Calibrating Length

When operating a Length Controller (either a Dual-Mode Lever System, or a High-Speed Length Controller) both Length In and Length Out must be calibrated. Please note: all references to In/Out are relative to the PC. This is different from past versions of DMC where In/Out was relative to the instrument being controlled. For example, "Length Out" in the software is the command signal sent to an instrument and corresponds to "Length Out" on the 604A Signal Interface which is connected to "Length In" on a length controller.

The leftmost panel on the calibration window, see Figure 12, is used to calibrate Length In and Length Out. The text entry boxes in the 'Volts' column are used to set the output voltage to levels which are close to the values we might expect to see in normal use. It is a best practice to set the calibration voltages to be equally spaced throughout the anticipated travel of the instrument, however this is not imperative. Note: one of the calibration output voltages MUST be set to zero (0) volts.

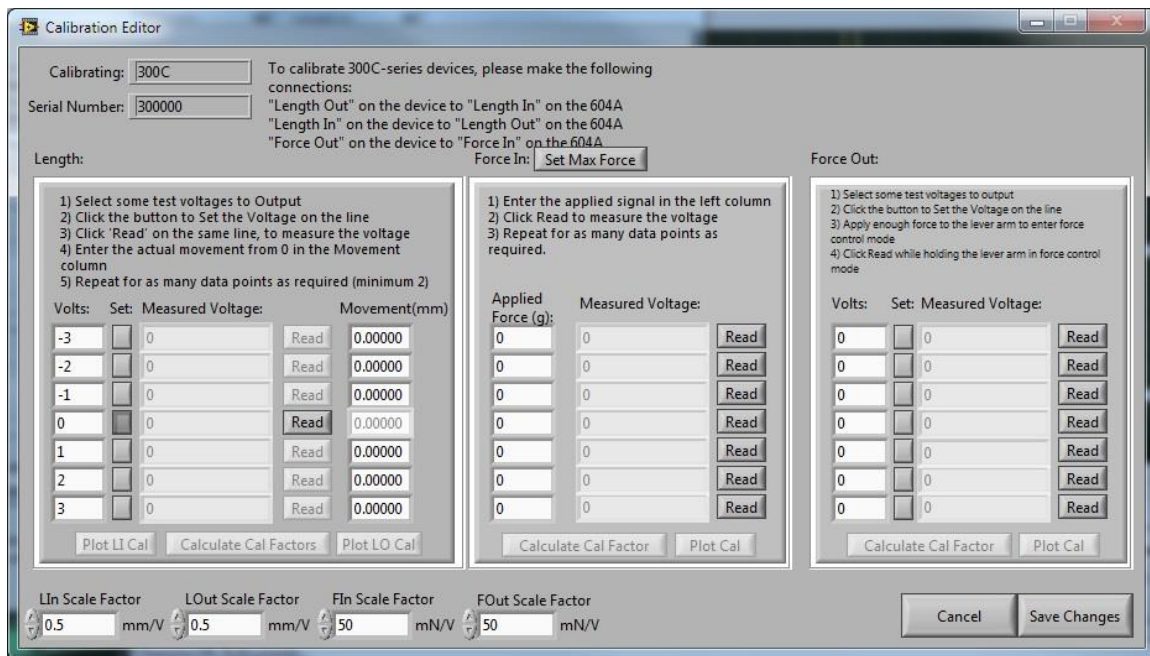


Figure 12: Calibration Editor Window

Enter seven calibration voltages and then click a button in the 'Set' column next to a calibration voltage. Normally you would start with the line that contains the zero calibration voltage and then change to each of the other lines. When you click the Set button the Length Out is set to the calibration voltage you entered. Next click the Read button on the same row. The Read button causes 100ms of data to be collected from Length In and then an average value is calculated and the result is placed in the Measured

Voltage text box. You must now measure the actual movement of the lever arm and enter this amount in the Movement (mm) text box on the same line. Repeat this for all 7 lines.

Once you have completed the table, the buttons at the bottom of the panel will become active. Click the Calculate Cal Factors button to populate the LIn Scale, and LOut Scale text boxes located at the bottom of the window. These values are calculated from a Least Squares fit of the calibration data. Note: the scale factors are in mm/volt. The values should be close to the factory defaults for the instrument. If they aren't, then redo the calibration ensuring that you make accurate measurements of the arm movement.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot LI Cal (Length In calibration plot) and Plot LO Cal (Length Out calibration plot) buttons.

4.1.2 Calibrating Inputs – Force In/Temp In/3rd Party In

Calibration is required for all instruments that provide an input to the DMC program. This section of the manual deals with the calibration of all input channels, except for the Length In channel from a Dual-Mode Lever System. Please note: all references to In/Out are relative to the PC. This is different from past versions of DMC where In/Out was relative to the instrument being controlled. For example, "Force Out" in the software corresponds to "Force Out" on the 604A Signal Interface, and gets connected to "Force In" on a 300C.

4.1.2.1 Force In Calibration of Aurora Scientific Dual-Mode Lever Systems

Click the "Set Max Force" button located above the Force In section of the window. This sets the force on the dual-mode system to its maximum, allowing input forces to be measured properly. Position the dual-mode force/length transducer such that the lever arm is horizontal and then hang a weight from the lever arm using an elastic (rubber) band. Now use the controls in the leftmost column of the Force In section to enter the applied force (measured in grams) of the weight hanging from the lever arm. The measured points do not need to be equally spaced in order to calculate a usable calibration factor, however, it is recommended that you space them as evenly across the full range as is possible. Click the Read button on the same row which records 100ms of data, calculates an average and then places the result in the field labeled Measured Voltage. Repeat this for the 7 rows in the table. Click the Calculate Cal Factor button to populate the Fin Scale text box located at the bottom of the window. This value is the calculated Least Squares fit of the calibration data. The Force In scale factor is in mN/volt. The value should be close to the factory default for the instrument. If it isn't then redo the calibration ensuring that you input accurate values for the applied force.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot Cal button.

4.1.2.2 Force In Calibration of Aurora Scientific Force Transducers

Locate the force transducer such that the output tube is vertical and pointing down and then hang a weight from the tube (fashion a small hook from wire and attach the wire to the output tube if required). Now use the controls in the leftmost column of the Force In section to enter the applied force (measured in grams) of the weight hanging from the tube. The measured points do not need to be equally spaced in

order to calculate a usable calibration factor, however, it is recommended that you space them as evenly across the full range as is possible. Click the Read button on the same row which records 100ms of data, calculates an average and then places the result in the field labeled Measured Voltage. Repeat this for the 7 rows in the table. Click the Calculate Cal Factor button to populate the Fin Scale text box located at the bottom of the window. This value is the calculated Least Squares fit of the calibration data. The Force In scale factor is in mN/volt. The value should be close to the factory default for the instrument. If it isn't then redo the calibration ensuring that you input accurate values for the applied force.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot Cal button.

4.1.2.3 *Temperature In Calibration of Aurora Scientific 825A TEC Controllers*

When calibrating a TEC controller the text in the central calibration area of the screen will change from force to temperature. Use the controls in the leftmost column to enter the applied temperature in degrees centigrade. The measured points do not need to be equally spaced in order to calculate a usable calibration factor, however, it is recommended that you space them as evenly across the full range as is possible. Click the Read button on the same row which records 100ms of data, calculates an average and then places the result in the field labeled Measured Voltage. Repeat this for the 7 rows in the table. Click the Calculate Cal Factor button to populate the calibration scale factor text box located at the bottom of the window. This value is the calculated Least Squares fit of the calibration data. The temperature scale factor is °C/volt. The value should be close to the factory default for the instrument. If it isn't, then redo the calibration ensuring that you input accurate values for the applied temperature.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot Cal button.

4.1.2.4 *Input Calibration of 3rd Party Instruments*

DMC can be used with third party instruments that have a +/-10V analog output with linear scaling. Use the controls in the leftmost column of the central calibration area to enter the applied signal in the units of the 3rd party device. The measured points do not need to be equally spaced in order to calculate a usable calibration factor, however, it is recommended that you space them as evenly across the full range as is possible. Click the Read button on the same row which records 100ms of data, calculates an average and then places the result in the field labeled Measured Voltage. Repeat this for the 7 rows in the table. Click the Calculate Cal Factor button to populate the Scale text box located at the bottom of the window. This value is the calculated Least Squares fit of the calibration data. The scale factor is in the units of the 3rd party instrument/volt.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot Cal button.

4.1.3 Calibrating Force Out

This calibration only applies to Dual-Mode Lever Systems. The force output is calibrated using the rightmost panel on the calibration window. Please note: all references to In/Out are relative to the PC.

This is different from past versions of DMC where In/Out was relative to the instrument being controlled. For example, “Force Out” in the software corresponds to “Force Out” on the 604A Signal Interface, and gets connected to “Force In” on a 300C.



NOTE: Before calibrating Force Out the Force In calibration procedure shown above must be completed.

The text entry boxes in the 'Volts' column are used to set the output voltage levels to the force controller. Select values that are expected to be seen in normal use. It is a best practice to set the calibration voltages to be equally spaced throughout the anticipated force range of the instrument, however this is not imperative. Note: one of the calibration output voltages should be set to zero (0) volts.

Enter seven calibration voltages and then click a button in the 'Set' column next to a calibration voltage. Normally you would start with the line that contains the zero calibration voltage and then change to each of the other lines. When you click the Set button the Force Out is set to the calibration voltage you entered. At this point, you must apply enough force to the lever arm to place the system into force-control mode, but you must not apply so much force as to drive the system into fault. Gently apply increasing pressure to the lever arm until the reading on the Force Out meter located on the front panel of the dual-mode system stops changing, and the arm starts to move. Hold the arm in this position, and click the “Read” button on the same row. The Read button causes 100ms of data to be collected from Force In and then an average value is calculated and the result is placed in the Measured Voltage text box. Repeat this for all 7 lines.

Once you have completed the table, the buttons at the bottom of the panel will become active. Click the Calculate Cal Factors button to populate the FIn Scale text box located at the bottom of the window. The value is calculated from a Least Squares fit of the calibration data. Note: the scale factors are in mN/volt. The values should be close to the factory defaults for the instrument. If they aren't, then redo the calibration ensuring that the lever arm is in force control mode before pressing the Read button.

After the calibration factors are calculated, the calibration data and curve fit can be plotted by clicking on the Plot Cal button.

4.2 Software Activation

The 610A Dynamic Muscle Control software must be activated before it can be used. Activation allows us to provide you with superior service and product updates.

To activate the software, you will need your serial number, and product key. These can be found on the foil S/N tag affixed to the PC or to the jewel case containing the software DVD. Below is an example of these.

Serial: 1501001

Product Key: A4AWOP

Upon starting the software for the first time, you will be presented with the software activation window.

Please complete the following procedure to activate your Aurora Scientific software.

- 1) Enter the Serial number and Product Key. The program will return a 15 character activation key, copy or write this down.
- 2) On a PC with internet access, point your web browser to:
<http://www.AuroraScientific.com/activate>
- 3) Enter the Activation Code unique to your computer returned by the program, your contact details and then click on the Activate! Button.
- 4) Copy or write down the 16 character license code returned by the webpage. The code is unique to your computer and cannot be used on another machine. Additional licenses must be purchased for use on multiple machines.
- 5) Enter the license code on the activation window to complete the activation process.
- 6) Once complete, exit and reopen the application.
- 7) Repeat as required for additional Aurora Scientific software.

Should you encounter any issues with this procedure, please contact Aurora Scientific by phone or email, and we will be happy to help you with this process.

4.3 Updating to a New Version of the 610A DMC Program

This section provides a brief description of the procedure required to update to a newer version of the 610A program.

Aurora Scientific is striving to make 610A the best program for the control of, and data acquisition from, muscle mechanics experiments. We are pleased to receive user comments about the program and suggestions for new functions. As a result of this pursuit, we periodically release new versions of the software.

New versions of 610A are available from our website at <http://www.aurorascientific.com/update/>.

Once you have received a new version of the program please follow the procedure listed below to update your program.

1. Close all open programs.
2. Copy the supplied update file to the PC to be updated
3. Run the setup.exe file found in the update package.
4. Follow the on-screen directions to complete the installation process.
5. You may be asked to reboot the computer upon completion. Do so if requested.

This completes the update procedure. In order to check that the update has been installed correctly start the program and click on Help > About. Compare the version number listed on the About screen with that shown in the update file name. If they are the same then you have successfully updated to the latest program version. If you experience any difficulties while updating your system please contact Aurora Scientific.

5 Performance Guarantee, Technical Support, Warranty and Repair Information

Aurora Scientific is dedicated to providing you with products that allow you to meet your research goals. For this reason we offer a performance guarantee, technical support and a new product warranty. Our performance guarantee ensures you purchase the correct instrument for your research. Technical assistance is always free and will be available for the life of your product. If you do have a problem with a product then please know that all Aurora Scientific products are covered by a three-year warranty covering both parts and labour. If you need to return a product to us for repair then consult the final section of this chapter for returns information.

5.1 Performance Guarantee

Our performance guarantee states: if for any reason a new product does not meet your research needs then you can return it to Aurora Scientific for exchange or a full refund. The performance guarantee only applies to new products and must be exercised within 60 days of receipt of the instrument.

5.2 Technical Support

Technical assistance is always free and will be available for the life of your product. Please don't hesitate to contact us if you have any technical support issues. Contact us by telephone, email, fax, or regular mail.

5.3 Technical Support Contact Information and Return Shipping Addresses

Canada, USA, South America, Middle East, Africa

Aurora Scientific
25 Industry St.
Aurora, Ontario, CANADA
L4G 1X6
Attn: RMA Returns
Tel: +1-905-727-5161
Fax: +1-905-713-6882
Email (all Aurora Scientific Offices): techsupport@aurorascientific.com
Web Site: www.AuroraScientific.com

Europe

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Hilton House
3 Ardee Road
Rathmines, Dublin 6, Ireland
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Tel: +353-1-525-3300
Fax: +353-1-443-0784

Asia, Australia, New Zealand

Aurora Scientific Asia
Unit B, 10/F
Charmhill Centre
50 Hillwood Road
Tsimshatsui, Kowloon, Hong Kong
Attn: RMA Returns
Tel: +852-3188-9946
Fax: +852-2724-2633

Distributors

Japan

Kantoh Electronics Co., Ltd.
1-25-14, Nakacho, Meguro-ku
Tokyo, 153-0065, Japan
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Fax: +81-03-5773-5029
Email: info@kantoh-elec.co.jp
Web site: <http://www.kantoh-elec.co.jp>

5.4 Warranty

Products manufactured by Aurora Scientific Inc. are guaranteed to the original purchaser for a period of three (3) years. Under this warranty, the liability of Aurora Scientific is limited to servicing, adjusting and replacing any defective parts that are of Aurora Scientific manufacture. Aurora Scientific is not liable to the customer for consequential or other damages, labour losses or expenses in connection with or by reason of the use or inability to use the products manufactured by Aurora Scientific.

Guarantee of parts and components not manufactured by Aurora Scientific shall be the same as the guarantee extended by the manufacturer of such components or parts. Where possible such parts returned to Aurora Scientific will be sent to the manufacturer for credit or replacement. Ultimate disposition of these items will depend upon the manufacturer's decision.

All shortages must be reported within ten (10) days after receipt of shipment.

Except where deviations are specified in literature describing particular products, the limited warranty above is applicable to all Aurora Scientific products, provided the products are returned to Aurora Scientific and are demonstrated to the satisfaction of Aurora Scientific to be defective.

Transportation costs of all products returned to Aurora Scientific must be borne by the customer and products must be returned to Aurora Scientific within three years after delivery to the original purchaser. Aurora Scientific cannot assume responsibility for repairs or changes not authorized by Aurora Scientific or damage resulting from abnormal or misuse or lack of proper maintenance.

Repair or service work not covered under the limited warranty will be billed at current service rates.

NO EXPRESS WARRANTIES AND NO IMPLIED WARRANTIES WHETHER FOR MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR USE, OR OTHERWISE OTHER THAN THOSE EXPRESSLY SET FORTH ABOVE WHICH ARE MADE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, SHALL APPLY TO PRODUCTS SOLD BY AURORA

SCIENTIFIC INC, AND NO WAIVER, ALTERATION OR MODIFICATION OF THE FOREGOING CONDITIONS SHALL BE VALID UNLESS MADE IN WRITING AND SIGNED BY AN EXECUTIVE OFFICER OF AURORA SCIENTIFIC INC.

5.5 Returning Products to Aurora Scientific for Repair

There are a few simple steps that must be completed before returning your product to Aurora Scientific.

1. Obtain a Return Material Authorization number (RMA#).

Contact our technical support department to obtain a RMA #. We require the serial number of the product along with your contact information, i.e. your name, institution, phone number and email address.

2. Package your instrument.

Use the original packaging materials if available. If you do not have original packaging then ensure that the product is wrapped in bubble pack and placed in a sturdy corrugated cardboard box. If you are returning a force transducer please place the transducer head in the plastic protective box and then wrap the plastic box in bubble pack and place it in a small cardboard box which can then be placed in the larger box along with the electronics. For force transducer repairs we require both the transducer head and the control electronics. Please don't send the power cord. When returning a muscle lever system wrap the motor in bubble pack and place it along with the lever arm in a small cardboard box and then place that box in the larger shipping container along with the controller. For muscle lever repairs we require the motor, lever arm, motor cable and control electronics. Please don't send the power cord.

3. Prepare Customs documents.

Canadian Clients: no customs documents are required, skip to step 4.

European Clients: no customs documents are required, skip to step 4 and ship to Aurora Scientific Europe.

Asia, Australia and New Zealand Clients: no customs documents are required, skip to step 4 and ship to Aurora Scientific Asia.

USA and Rest of the World Clients: You must include a Commercial Invoice (CI) with the shipment. Please click this link to download a blank CI.

You can also prepare the commercial invoice yourself instead of using the downloadable form. Print the document on your company's letterhead and include the following information: Date, Shipper's Name, Address and Phone Number (your company information), Consignee's Name, Address and Phone Number (Aurora Scientific Inc. is the Consignee), Country of Origin of Goods (this will be Canada if you purchased the instrument from Aurora Scientific or USA if your product was purchased from Cambridge Technology), Conditions of Sale (include the following statement: GOODS RETURNING TO FACTORY FOR REPAIR, TEMPORARY IMPORT), Number of Packages (normally 1), Description of Goods (e.g. Model 300B Muscle Lever System, Serial Number 1111), Quantity of Each Item (normally 1) and Value for Customs Purposes (the original purchase price of the instrument).

Place three (3) copies of your CI in an envelope and mark the outside CUSTOMS PAPERS ENCLOSED. Attach the envelope to the outside of the box.

4. Choose a shipper and prepare the waybill.

European Clients: ship your instrument to Aurora Scientific Europe in Dublin, Ireland.

Asia, Australia and New Zealand Clients: ship your instrument to Aurora Scientific Asia in Hong Kong.

Canadian, USA and all other Clients: ship your instrument to Aurora Scientific in Ontario, Canada.

You may ship your instrument back to us via the courier of your choice or via parcel post. If possible we prefer that you ship via FedEx. You are responsible for both the shipping and brokerage charges so please mark the waybill accordingly. Please don't ship freight collect. Shipments sent freight collect will be received but you will be invoiced for the shipping charges when your instrument is returned.

5. Prepare and send a purchase order.

After we receive the instrument we will evaluate it and contact you with the estimated repair cost. We require a purchase order before we can repair and return your instrument. Please fax or email us the purchase order at your earliest convenience.

6 Specifications

Minimum Requirements for the PC

Processor: Dual-core Intel or AMD
RAM: 2 GB
Hard Disk: 40 GB
Operating System: Windows XP

Recommended PC Specifications

Processor: Quad-core Intel or AMD
RAM: 4 GB
Hard Disk: 500+ GB
Operating System: Windows 7, 64 bit

A/D Card

Analog Input

Number of Channels: 8 differential
Resolution: 16 bits (1 part in 65536 parts)
Maximum Sample Rate: 100,000 samples per second.

Analog Output

Number of Channels: 2
Resolution: 16 bits (1 part in 65536 parts)
Maximum Output Rate: 100,000 samples per second.

Digital I/O

Number of Channels: 24
Type: TTL

Operating System

Type: Windows XP/Vista/7/8

7 Appendices

7.1 Appendix A – 610A Data File Structure

DMCv5.0 Data File

Sample Frequency (Hz): 5000

Calibration Data:

Channel	AI0	AI1	AI2	AI3	AI4	AI5	AI6	AI7	AO0	AO1
Units	°	mN	TTL					°	mN	
Scale (units/V)		2.005352		1000.000000		0.200000		0.000000		0.000000
	0.000000	0.000000		0.000000		2.005352		1000.000000		
Offset (units)		0.000000		0.000000		0.000000		0.000000		0.000000
	0.000000	0.000000		0.000000		0.000000		0.000000		

Test Comments:

Test Data in Volts:

Sample	AI0	AI1	AI2	AI3	AI4	AI5	AI6	AI7	AO0	AO1	Stim
0	-9.429405	-0.287263	-0.154864		-0.154864		-0.077631		-0.035445		-0.076009
	-0.044531	-0.252865		0.000000		0.000000			0		
1	-0.000723	-0.008836		0.648941		0.926720			0.238439		-0.008511
	-0.015001	-0.231123		0.000000		0.000000			0		
2	-0.000398	-0.006240		0.856302		1.315155			0.487661		0.095656
	0.024913	-0.195428		0.000000		0.000000			0		
3	-0.000398	-0.004293		0.839427		1.401474			0.681392		0.215724
	0.077483	-0.147725		0.000000		0.000000			0		
4	-0.000398	-0.003644		0.753108		1.356692			0.817361		0.338063
	0.140113	-0.092559		0.000000		0.000000			0		
5	-0.000398	-0.005591		0.651213		1.277512			0.905627		0.452939
	0.211505	-0.032525		0.000000		0.000000			0		
6	-0.000074	-0.003319		0.575927		1.198657			0.958197		0.554834
	0.286466	0.032052		0.000000		0.000000			0		
7	-0.000723	-0.001372		0.483767		1.056198			0.968906		0.638232
	0.361427	0.102146		0.000000		0.000000			0		
8	-0.000398	-0.001372		0.383169		0.893295			0.944243		0.699889
	0.430548	0.172564		0.000000		0.000000			0		
9	-0.000074	-0.001047		0.298473		0.743373			0.895567		0.740128
	0.493502	0.242009		0.000000		0.000000			0		
10	0.000251	-0.000074		0.229677		0.611298			0.832288		0.758625
	0.546397	0.308208		0.000000		0.000000			0		

7.2 Appendix B – 610A Protocol File Structure

DMCv5.3 Protocol File

Input Sampling Frequency: 2000Hz

Output Sampling Frequency: 2000Hz

Protocol Type: Unitized

Wait(s)	Then(action)	On(port)	Units	Parameters
1.000000	Stimulus	Length Out	0,100,10,5,1	
1.000000	Trigger	Length Out	1	
1.000000	Trigger	Length Out	2	
1.000000	Trigger	Length Out	3	
1.000000	Trigger	Length Out	4	
1.000000	Trigger	Length Out	0	

7.3 Appendix C – 610A Sequencer File Structure

```
DMCv5 Sequence File
Base File:  ECC_EDL
Protocol File Timed? TimeToWait  FileMarker
C:\20HZ_FF.dpf      Timed  300.000    a
C:\40HZ_FF.dpf      Timed  300.000    b
C:\60HZ_FF.dpf      Timed  300.000    c
C:\80HZ_FF.dpf      Timed  300.000    d
C:\100HZ_FF.dpf     Timed  300.000    e
C:\120HZ_FF.dpf     Timed  300.000    f
```

7.4 Appendix D – 610A Log File Structure

```
12:27:31.253: DMC Opened, verified Activation
02:42:07.186: DMC Opened, verified Activation
02:42:16.629: User Comment:  Here is an example comment!
02:46:20.391: DMC Opened, verified Activation
02:46:30.514: Started Test
02:46:39.315: Saved Data File to: C:\Users\ASI\Desktop\test2.ddf
```