ACUTRONIC

Measuring Frequency Response on the Acutrol3000

Technical Manual

TM-9392

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1 Introduction

The Acutrol3000 has built-in features that allow the user or system configuration specialist to measure the frequency response of the axes being controlled. The algorithms are implemented in both the RT computer and the GUI computer. The execution of the tasks are partitioned as follows:

a) All process control is via the GUI interface, where the first task is to configure and initiate Data logging.

b) Data is logged for the duration of a sinusoidal motion sweep over the frequencies of interest.

c) Motion/Servo data is logged by the RT computer of the Acutrol3000 controller and is temporarily stored in RAM.

d) After the data is logged, it is saved to a file on the RT computer and is transferred by FTP to the GUI computer.

e) This file is loaded, and can be viewed by selecting variables and scrolling through the data records. Also, two variables can be graphed against time, or X-Y plotted.

f) Frequency response is computed as the spectral ratio of any two variables in the data set.

g) Frequency response data can be saved as data points or as a graphic screen capture.

2 Setup Procedure

The setup procedures involve selecting variables to log, configuring the data logging parameters, and configuring the axis control for a sinusoidal motion sweep.

2.1 Selecting Variables

The first question is which variables to Log. Since 8-10 variables can easily be logged, it is possible to log one set of data and produce many frequency responses.

Any floating-point variable in the system can be logged allowing a wide range of options for open and closed loop frequency response measurement. The following table lists typical variables that are used to fully document the performance of a servoed axis.

Variable	Description
x008	Position Command
x082	Estimated Position Feedback
x166	Raw Position Feedback
x164	Compensated Servo Output
x030	Position Error
x061	Observer Error
x043	Observer Acceleration Feed Foreword
x034	Rate Error

The data log variable list is specified in the GUI [Data Log/Configure] panel. A variable is specified for each channel that is to be logged using the following procedure:

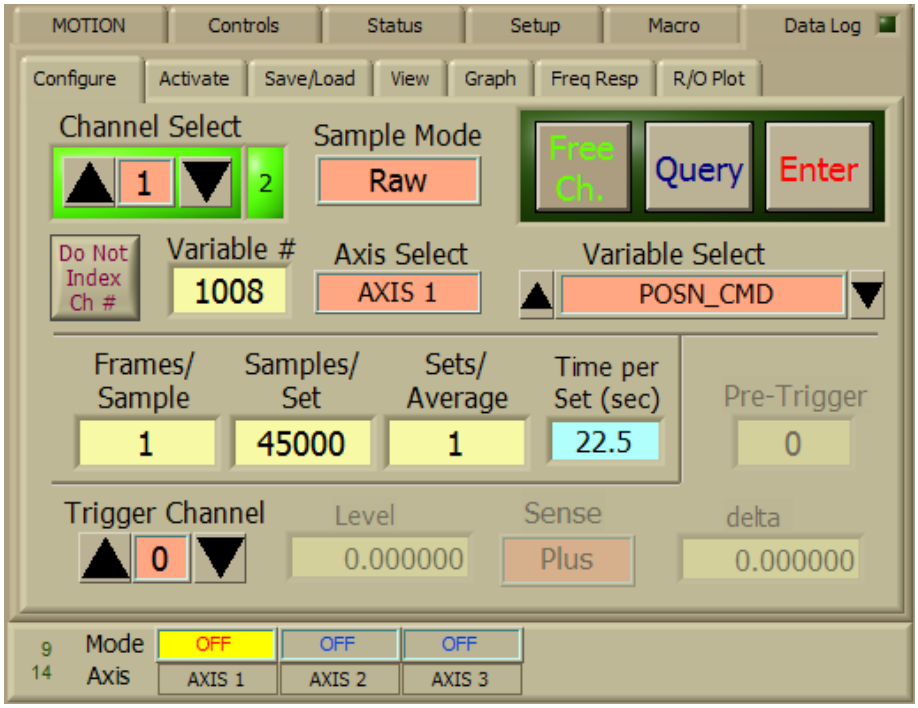
a) Select a channel, enter a variable number in the numeric keypad, and touch the **Variable#** control.

b) Select **"RAW"** for the data **Sample Mode**.

c) Enter variable to add it to the list.

Variables can be changed by entering a new value or deleted by pressing the **Free Ch.** button. It is not necessary for channels to be used sequentially, but

is more confusing when reviewing the logged data. Variables can also be selected by using the **Variable Select** pick box and the **Axis Select** control. When switching to another axis, it is convenient to use the **Axis Select** to change the axis while retaining the root variable number. When entering a list of variables, the **Auto Index Variable#** feature can be selected. Be careful not to enter the variable number 0 or other variables that are not defined, or not floating point-formatted variables.

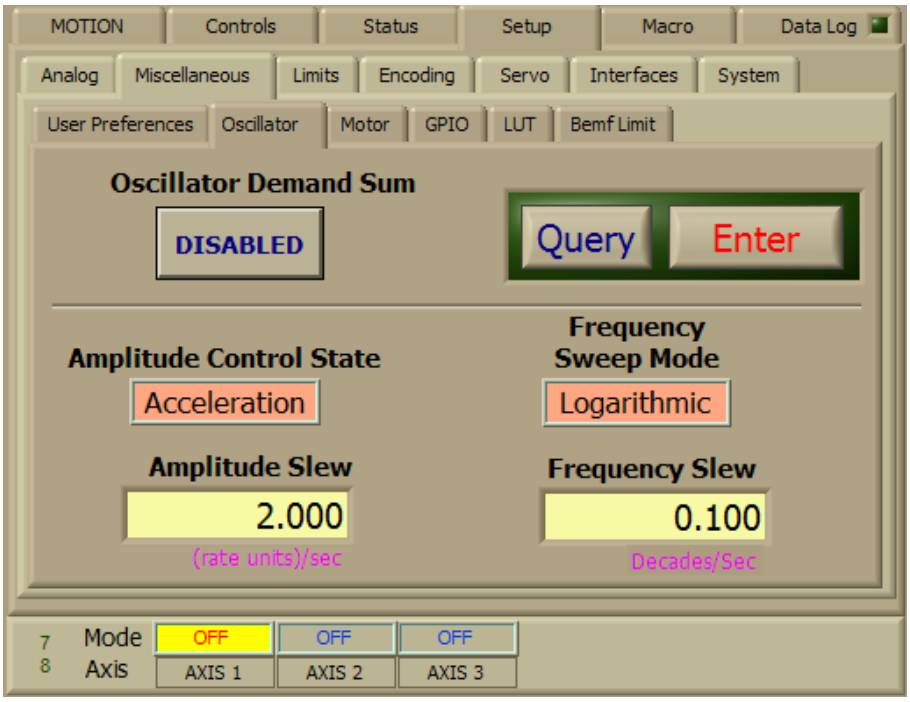


2.2 Swept Sine Setup

This section defines the preparation for generating a logarithmic frequency sweep in the Synthesis profiling mode. The steps include setting up the default operation of the Synthesis mode, initializing the starting point for the frequency sweep in Synthesis mode, and verifying linear operation of the sweep.

a) Defaults - On the GUI, select the [Setup/Miscellaneous/Oscillator] panel and configure the Synthesis mode operation as indicated below and in the example panel:

- Oscillator Demand Sum – DISABLED
- Amplitude Control State – Acceleration
- Frequency Sweep Mode – Logarithmic
- Amplitude Slew – 0.5 to 5 deg/sec depending on system
- Frequency Slew (rate) – 0.1 decades/second



Acceleration is selected for the Amplitude Control State to optimize the stimulation of the axis over the entire frequency range while minimizing the chance of saturation the servo control loop(s). While the frequency is slewed, the amplitude of the position sine wave is automatically adjusted to keep the acceleration peak amplitude a constant value.

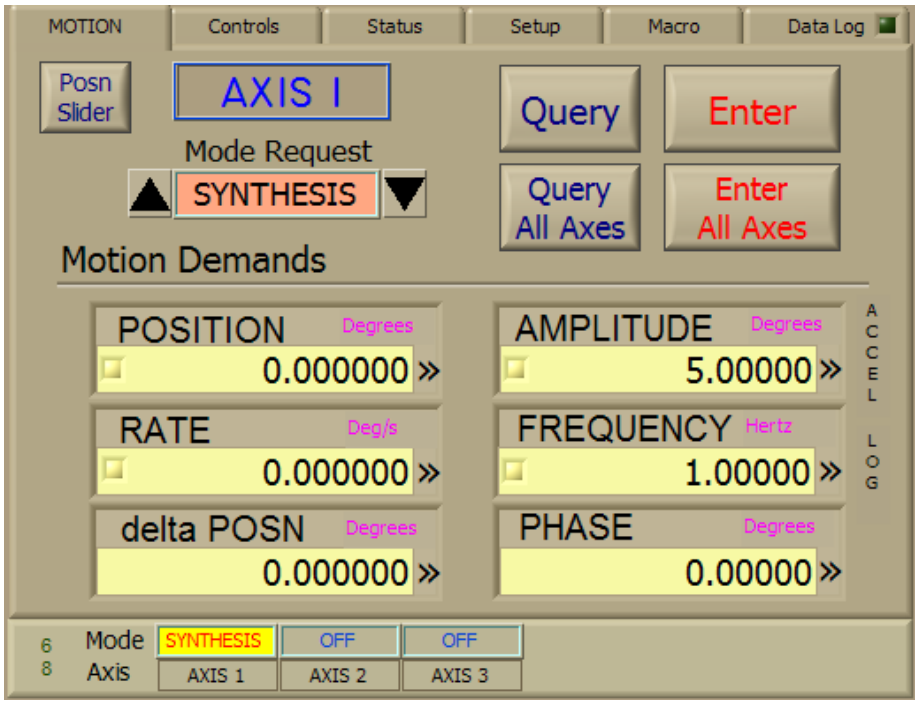
b) Start Frequency - The next step sets up the Synthesis mode operating point using the Motion demand Panel. This procedure assumes that the starting frequency is 1 Hz, the normalization frequency for Synthesis mode.

- Enter 1 Hz as a starting **Frequency**

- Determine the appropriate peak acceleration that the system is capable of sustaining. A candidate starting point is one-half the Factory Acceleration Limit for the axis. Compute and enter the (position) **Amplitude** as follows:

$$Amplitude(pos) = Accel(peak)/(2pi*1Hz)^2 = Limit(FactoryAccel)*0.0127$$

- Make sure that the Acceleration Limit set for Synthesis mode is significantly greater than the operating Acceleration.



c) This step verifies that the axis can operate over the frequency range of interest without saturation.

- Configure a Readout Window to display the OSC_FREQ variable x275 for the axis under test. This step is optional and allows monitoring the instantaneous frequency command.
- Close the servo in the axis of interest.
- Switch to Position Mode and command the position where the frequency response is to be measured.
- Command Synthesis mode; the axis should begin oscillating at 1 Hz and produce dynamic but smooth motion.
- If the motion is not as expected, verify that no limits are being violated by selecting the [Status/System] panel and displaying the ACP AxDYN status word.
- Command 100 Hz (or what ever the maximum frequency for measuring the response) for the Synthesis **Frequency**. Verify that the oscillation slowly slews in frequency to the final set point.
- The frequency sweep ratio is F_{FINALI}/F_{START}; in this case 100/1 or two decades. With a slew rate of 0.1 decades per second (10 seconds per decade) the duration of the sweep is 20 seconds.
- Return to Position Mode until ready to start logging data.

2.3 Data Log Parameters

This section sets up the basis for sampling data using the [Data Log/Configure] panel.

Caution: When entering the sample configuration data in this section, be sure that an active channel is selected to prevent accidentally creating a bogus channel.

a) For the purpose of data logging, it is generally best to log data on every sample frame; the **Frames/Sample** should be set to 1.

b) Data sets will not be averaged thus the number of **Sets/Average** should be set to 1.

c) The time for a set of data is computed and displayed in the Time per Set indicator:

*Time(set) = (# of) Samples/Set X (# of) Frames/sample X Frame Period**;*

d) The number of samples is computed given the time for a sweep computed in the previous section:

*(# of) Samples/Set = Time(set) / { (# of) Frames/sample X Frame Period**}*

For Example:

Given a 20 second sweep time, and an update rate of 2 kHz (frame period = 0.0005), the number of samples is computed:

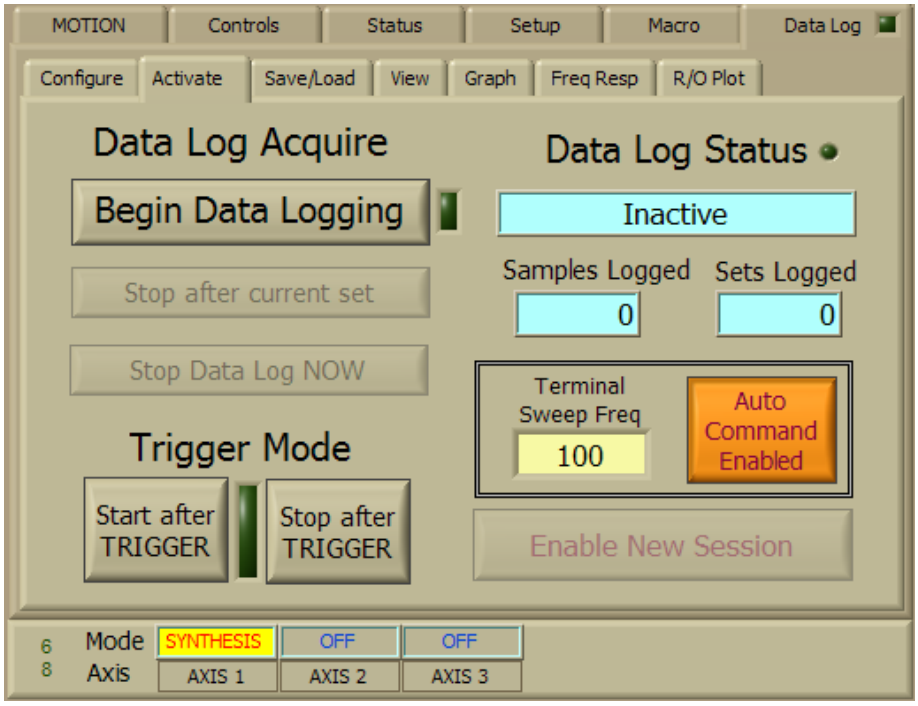
(# of) Samples/Set = 20/0.0005/1 = 40000

e) To ensure that data is logged during the entire frequency sweep, it is customary to add an additional 5% or so to the number of samples taken. For this example a reasonable number of samples would be 45,000 as indicated in the [**]Configure panel above.

[**] Frame Period is the reciprocal of the Frame Update Frequency, which can be viewed in the [Setup/System/System Defaults] panel.

3 Logging Data

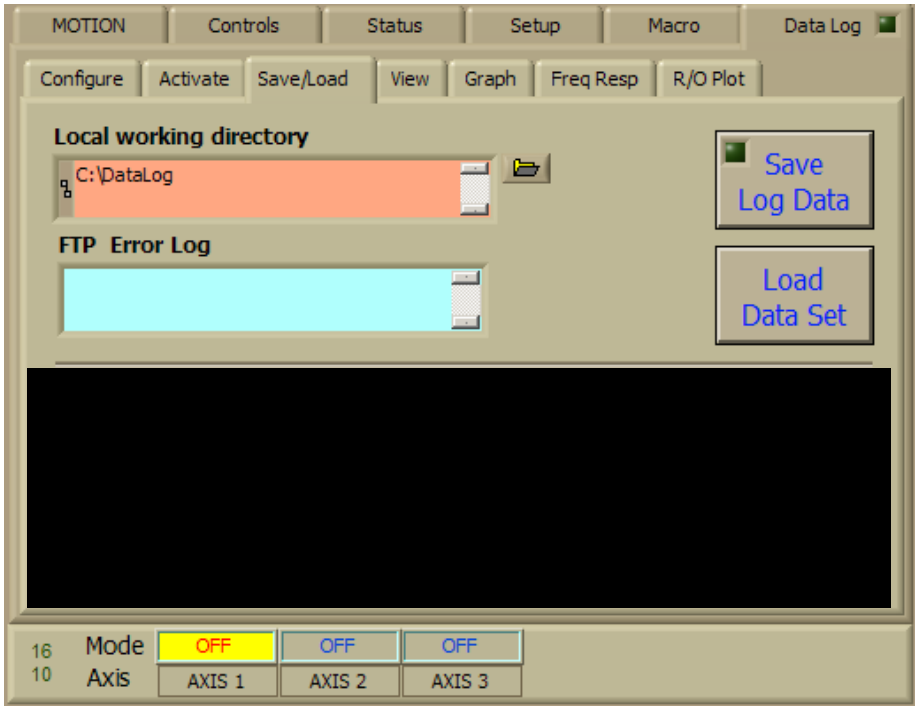
Data logging is initiated in the [Data Log/Activate] panel. The Data Log trigger modes are not used to synchronize with the sweep; rather, the frequency sweep is started as a result of initiating data logging.



- Set the Terminal Sweep Frequency to 100 Hz (or what ever is the maximum frequency of interest)
- Toggle the **Auto Command** button to the **Enabled** state.
- Switch back to the Motion panel and select the 1 Hz starting frequency and put the axis in Synthesis mode.
- After the terminal state is achieved, switch back to the [Data Log/Activate] panel and select **Begin Data Log**.
- The axis will begin sweeping and the progress of data logging is indicated in the **Data Log Status** on the Activate panel. Data logging should not end before the frequency sweep is complete.
- To log another frequency sweep, it is first necessary to reset data logging by pressing the **Enable New Session** control, then repeat the previous steps of this section.

4 Saving and Loading a Data Set

The process of saving and loading a data set is currently managed by the system operator in the GUI to provide flexibility in the handling the data. Refer to the [Data Log/Save/Load] panel.



- Note that the default **Local Working Directory** is specified in the GUI computer; however, if logged data needs to be saved for external use, the working directory can be changed to select an external USB FLASH drive using the directory pick box.

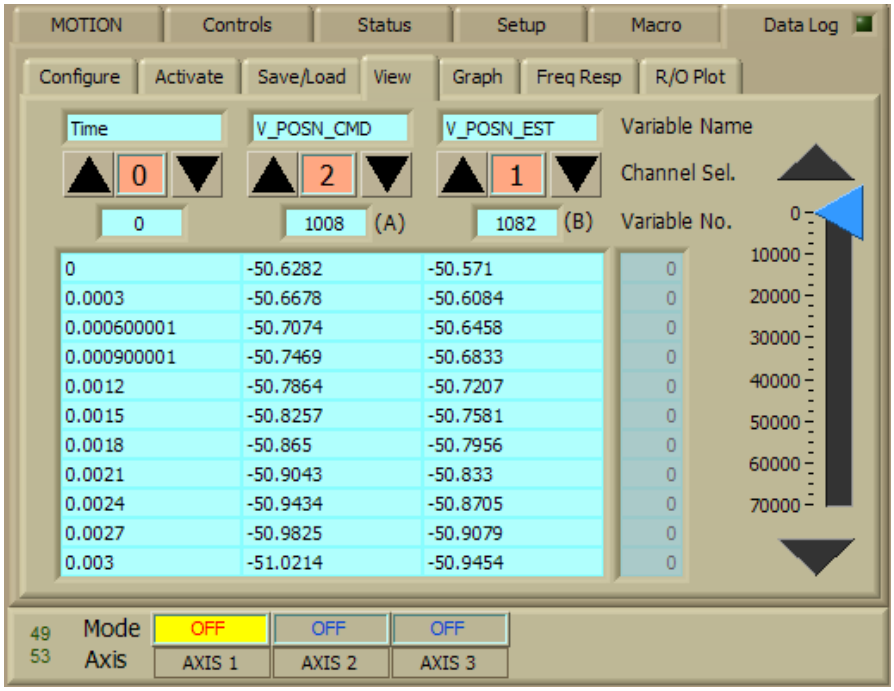
- Press the **Save Log Data** button to transfer RAM based logged data to a temporary file in the RT computer. This command also copies the file using an FTP client to the Local Working Directory. The default name of the file is LOG_A3KDATA.dlog.

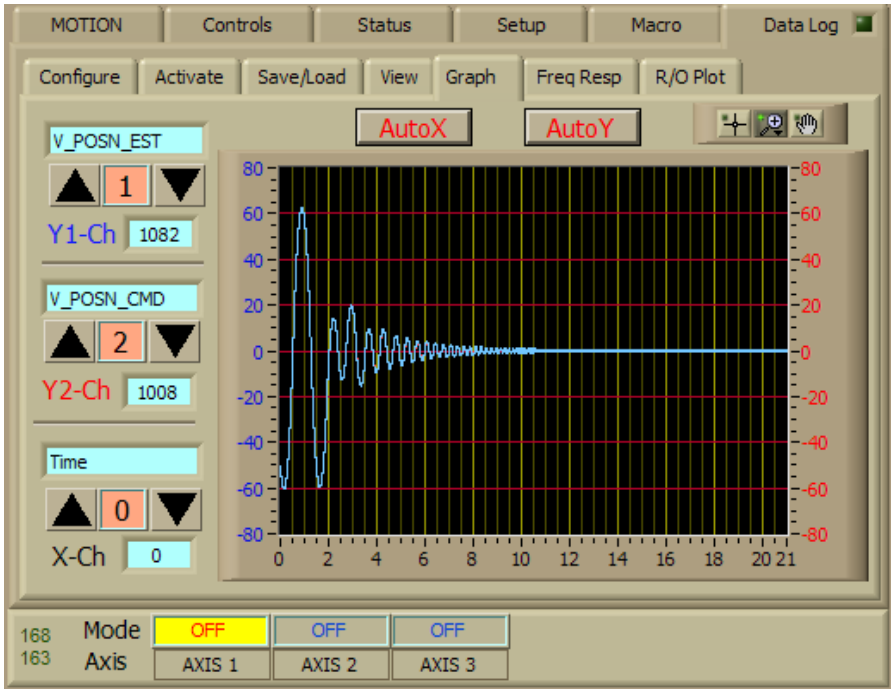
- Press the **Load Data Set** button to bring up a file dialogue box. Select the default file to load the most recent logged data. While in this dialogue box, the file name can be renamed to prevent it from being rewritten by the next data log save operation. A keyboard must be connected to the system to be able to edit the name.

5 Frequency Response Plots

5.1 Creating a Frequency Response Plot

The data is loaded and may be viewed in the [Data Log/View] panel or plotted using the [Data Log/Graph] panel.





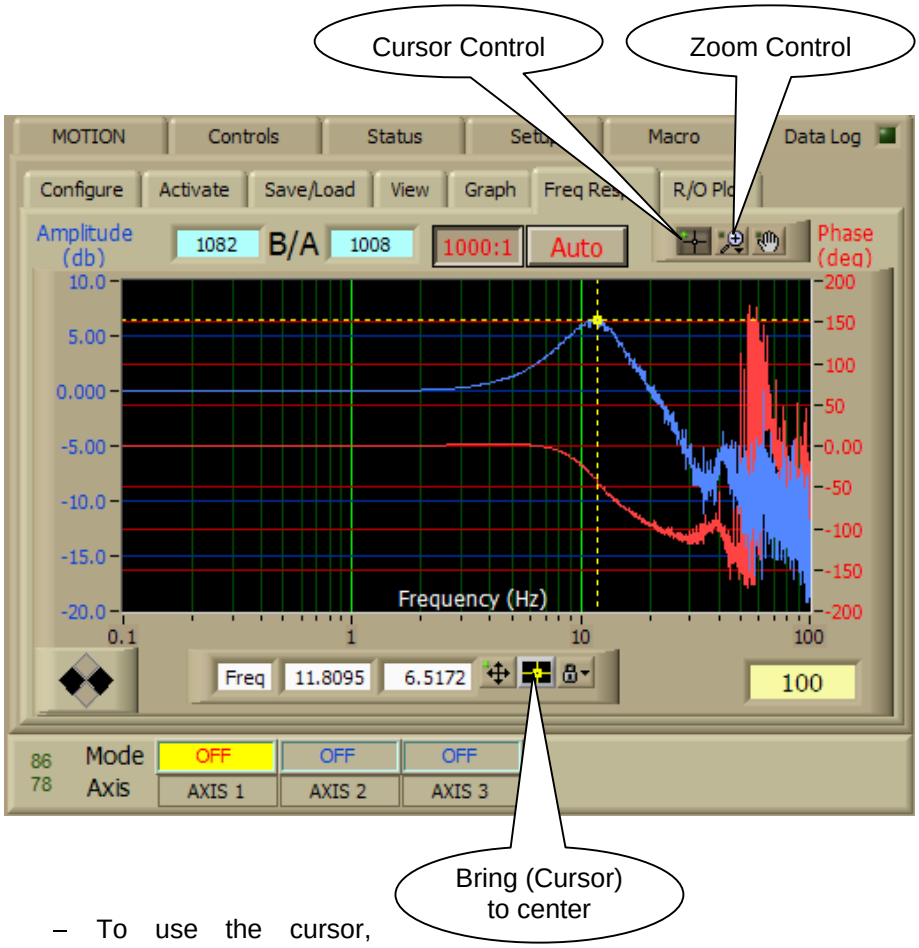
- Review the time response data to verify that the frequency sweep resulted in a clean envelope and that the data does not exhibit saturated states. Saturation would be most evident by looking at the compensated Servo Output variable x1064.

- Using the View panel, note that the 2nd and 3rd columns are identified with an (A) and a (B) respectively. The variables selected in these two columns represent the variables that will be used to compute the frequency response plot. The Frequency response plot is computed as the ratio of spectrums of the response variable divided by the excitation variable (B/A).

- Select the desired Response variable (B) in the 3rd column.

- Select the desired Excitation variable (A) in the 2nd column.

- Switch to the [Data Log/Freq Resp] panel to view the frequency response.



- To use the cursor, select the Cursor Control; it may be necessary to use the **Bring to Center** feature to locate the cursor in the window. The cursor can be dragged over the plot to the frequency of interest to display frequency

and the value of the plot at the cursor. The cursor can also be dragged from one plot to the other.

- To Zoom to a portion of the plot, select the Zoom control and pick the zoom mode. Use Auto/Manual to restore the plot
- Use the 100/1000:1 frequency span control to show 2 or 3 decades.
- The maximum frequency plotted is set by default based on the frequency range specified in the data log header. This value can be changed by entering a new value from the key pad in the (yellow) control located at the upper end of the frequency grid.

5.2 Typical Frequency Plots

The following table lists various frequency response plots that may be measured for the purpose of evaluating the performance of an axis. It is by no means is an exhaustive summary; the system analyst should feel free to be imaginative with the hundreds of variables that are available.

For example, the door opens a bit, when you realize that data can be logged from multiple axes allowing the measurement of cross-axis sensitivities and disturbance responses.

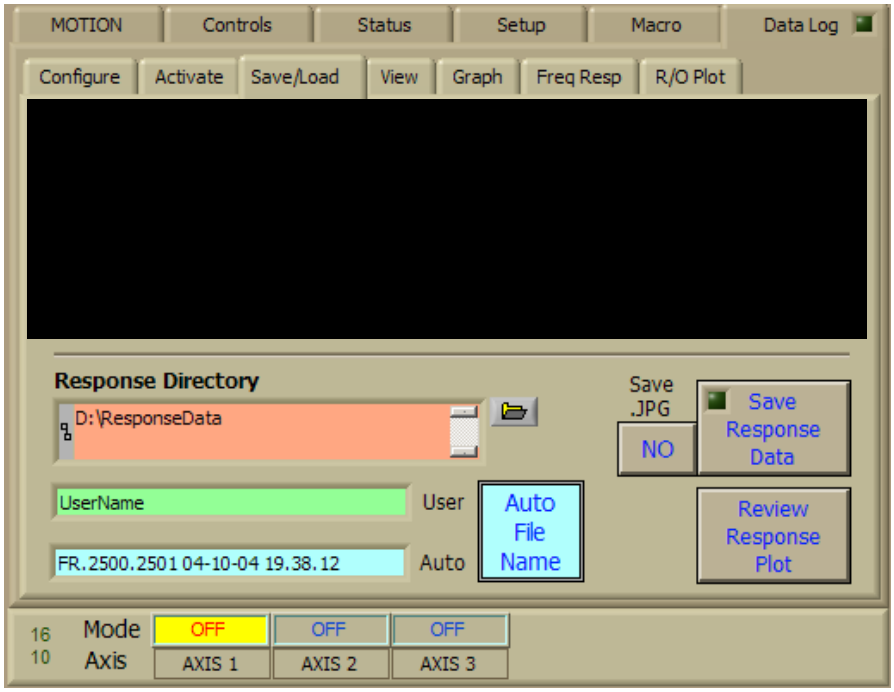
Command Variable	Response Variable	Response Description
x008	x082	Closed Loop Estimated Position Response
x008	x166	Closed Loop Measured Position Response
x166	x082	Observer Estimated Position Tracking Response
x061	x043	Observer Inertia Scaling (Residual) response
x164	x166	Open Loop Position Plant
x008	x030	Position Tracking Error Response
x034	x083	Compensated Open Loop Estimated Rate Plant
x030	x083	Compensated Open Loop Estimated Position Plant

5.3 Saving/Loading Plots

As discussed earlier, logged data can produce a large number of useful frequency response plots. Saving the complete logged data file is the simplest way to save as much information as possible to define the response of an axis. The Log data file is hard to use in third party applications because

of the data storage structure and because it is time response data and must be transformed to provide useful frequency response plots. The data log file can always be loaded and viewed using the Acutrol3000 GUI.

An alternative to saving the log data is to generate the various frequency response plots and save the frequency response data (header, frequency, amplitude, and phase) in CSV format. Also, a plot .JPG can be optionally saved for easy integration into user or acceptance test documents.



To save a frequency response plot, follow the steps below:

- Select B/A variables and plot the frequency response. Displaying the frequency response plot updates the data structure that will be used in the save command.

- Select the Save/Load panel and choose a method for naming the save file for the response. Select **User File Name** and enter a unique user define name from the alphanumeric keyboard on the display function bar at the top of the Acutrol3000 screen. Or select **Auto File Name** and allow the system to generate a unique file name that includes plot specific information (cmmd var, resp var, date, and time).

- The default **Response Directory** points to the external USB flash drive but can be changed using the directory select pick box.

- Select “Yes” to save .JPG screen plots to a file with the same base name as the frequency response.

- Press the **Save Response Data** button to initiate the file transfer(s).

A saved frequency response can be loaded for review in the frequency response plot panel by selecting the **Review Response Plot** button. Switching to any of the other View, or Graph panels reverts back to displaying/processing the current log data set.