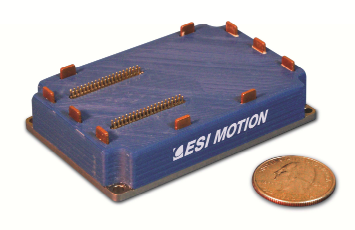

Controller User's Manual

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Revision B Updated on 10/23/2015

ESI Motion Document 100266

Revision Control

Revision	Date	Change Description
A	1/15/2015	Initial Release
B	10/23/2015	Updated to coincide with the Trouble-shooting guide release and to add new Controller features.

TABLE OF CONTENTS

Referenced Documents

ESI Document 100249, Mighty Mite Installation Manual
ESI Document 100236, Mighty Mite Datasheet
ESI Document 100211, ESI Motion's CAN Protocol
ESI Document 100121, ESI Motion's RS422 Protocol

1 INTRODUCTION

ESI's Dragon Motor Control system is a complete ruggedized, off-the-shelf motor controller system solution which includes ESI's rugged controller and power driver boards, an integrated EMI filter, military-grade submersible case, controller software, and user-friendly GUI.

The Mite system is ideal for military, aviation, automotive or other heavy industrial applications operating in outdoor, high temperature, high vibration, or other extreme environmental conditions.

2 NAMING CONVENTIONS

The descriptions below are applicable to each motor controlled, and because of the number of configuration and run-time variables, there is a readable prefix for common variables:

- There are common configuration and measurement variables, and for dual/multiple-motor controllers, there are configuration and measurement variables for each motor-control subsystem. Each Motor-control subsystem is referred to MotorA (primary / single-motor controller), MotorB (for a dual / multiple motor-controller), and in some custom applications MotorC and MotorD (for the third and fourth motor-controller subsystem).

- The prefix for Current loop variables for Motor A, Motor B, and Motor C is Ma, Mb, and Mc, respectively. For example the Motor-A IQ command variable is Ma.IqCmd, and the Motor-B Minimum Current Command is Mb.MinCurrentCommand. Each of these variables is referred to below as Mx.VariableName.

- The prefix for Velocity loop variables for Motor A, Motor B, and Motor C is MaVL, MbVL, and McVL, respectively. For example the Motor-A user velocity command is MaVL.RPMUserCommand, and the Motor-B RPM error to compensate is MbVL.RPMError. Each of these variables is referred to below as MxVL.VariableName.

- The prefix for Motor configuration variables for Motor A, Motor B, and Motor C is MotorA, MotorB, and MotorC, respectively. For example the Motor-A inductance is MotorA.Inductance, and the Motor-B feedback type is MotorB.FeedbackType. Each of these variables is referred to below as MotorX.VariableName.

3 THE HIDS APPLICATION

First begin by running the application from the Windows Start menu. You will find the application icon named “HiDS” under the “ESI Motion” folder. Once you launch the application, the first screen you will see will be the connection dialog.

3.1 Connecting to a Controller

HiDS supports different methods of connecting to target devices. The type of connection you will choose depends on your particular environment and usage.

ESI recommends running over CAN any time power is applied to the motor since USB is less noise tolerant than CAN. USB is convenient for things like firmware updates and parameter loading when motor power is not present.

To connect via USB, select a target device from the list provided. If you do not see your device in the list or if there are no devices listed, check your connection and ensure that your device is powered on. When viewing the connection dialog, the application will auto-discover your device and refresh the list when you plug in your device. You can also press the **Refresh** button to force a manual refresh of available devices.

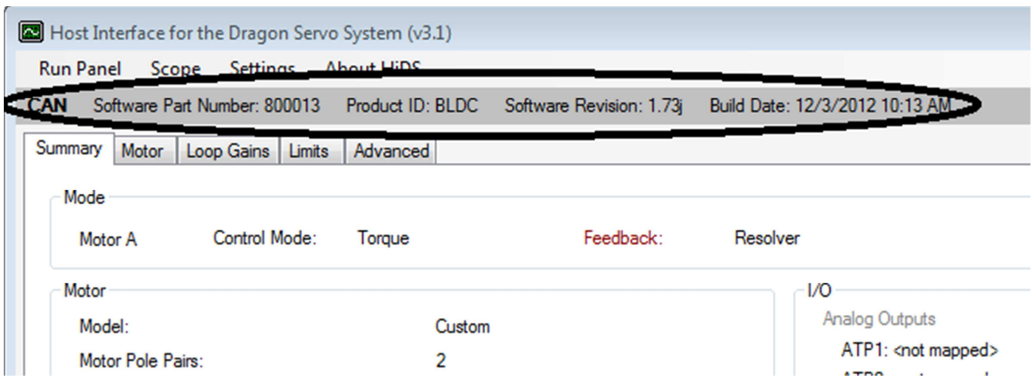
The CAN tab allows you to connect to a device via CAN and requires the use of an **IXXAT USB-to-CAN compact adapter**. This adapter allows one to communicate with the device using CAN via a USB port on your computer. Can connections require that you select the CAN channel of your device and the appropriate baud rate. The default CAN channel is 0 with a baud rate of 1M. Note that some customer applications may have unique default CAN settings.

The third available selection for connection type is legacy Virtual-COM-port USB Controllers. This method also communicates with the device over USB but uses a previously released virtual COM port (i.e. COM5 or COM27) driver. If your Controller uses the legacy USB driver, it can be upgraded to the current USB driver as this is the preferred and more robust USB connection.

After you have selected your device and configuration, press **Connect** to begin communicating.

3.2 The HiDS User Interface

The main HiDS user interface will be displayed after connection to the device. At the top of the screen you will see a menu bar where you can access various features of the application discussed below. Directly below the menu bar, you will see the device connection display. This display shows the type of connection to the current device, the device software part number, the product Id, the software revision, and the build date. This information can be helpful in identifying the version of firmware currently running on the device.



Below the connection display there is a tabbed information display, defaulting to the Summary tab. This tab contains a summary of critical information about your device. The other tabs provide access to key configuration parameters of the device that you can modify according to your specific requirements. The sections below will discuss key areas of each tab in more detail.

3.2.1 Editing Parameter Values

On the Motor, Loop Gains, and Limits tabs, you will see several text boxes that display the current values of key parameters of your device. If you click in one of the available text boxes and change the value, the value will be written to the device and you will briefly see a confirmation that the value has been changed in the status bar at the bottom of the screen.

If you are entering a value in a field and decide you don’t want to send it to the drive, you can press the Esc key on the keyboard before clicking on a different field and the parameter will revert to its previous value. You can also force the value to be updated on the device immediately by pressing the Enter key while the cursor is active in a text box.

3.2.2 Device Compatibility

In some circumstances, the version of the HiDS application may be newer than the firmware on your target device. In this case, there may be some fields that the HiDS application supports that your device does not support.

When this occurs, the application will show those textboxes with a red background indicating that they are unavailable fields.

3.2.3 Summary Tab

The summary tab displays a read-only view of key device configuration parameters.

3.2.4 Motor tabs

The top section of the motor page is where you can configure key motor-related parameters for your device. The motor Resistance, Inductance, and Voltage Constant (Ke) are used inside the ESI Motion Controller in the units of Line to Neutral, as those units are required for the vector control mathematics. Resting the mouse over each of these values will display the conversion from Line to Neutral to Line to Line.

The bottom section of the motor page contains feedback related configuration values.

3.2.5 Loop Gains tabs

The loop gains tab is dynamically configured based on the **Control Mode** selection you make at the top of the screen. In the current loop section, you can compute the **Ki** value from the **Integral Time Constant** or vice versa using the **Compute Ki** and **Compute ITC** buttons.

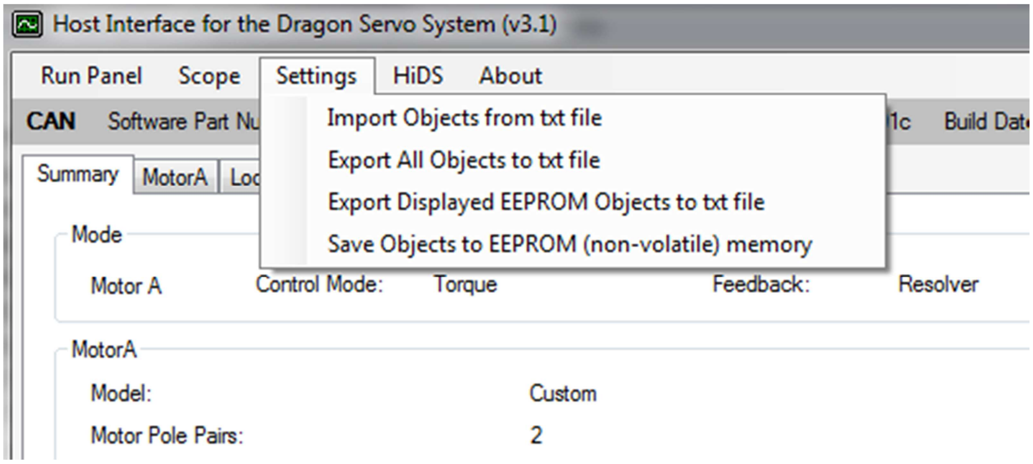
3.2.6 Limits tabs

The limits tab provides a checkboxes to enable or disable the available fault and warning checks. The fault and warning limits can be entered if it is enabled. The checkbox labeled "Enable" can also be checked to allow entry of the **Regen Voltage** (if supported by the Controller).

3.2.7 Importing, Exporting, and Saving Settings

In the Settings menu selection, one can export all device settings to a text file. Select **Settings->Export Objects to txt file**, and you will be prompted to select a file name and location where you would like the export file to be stored. This file will contain the current value of all objects in the device. This file could be imported; however this large file is not typically imported as only a few variables need to be modified for a particular motor or operation.

Alternately **Settings->Export Displayed EEPROM Objects to txt file** allows you to export a text file that only has permanent variables written. The above export writes all values, which may be useful in some cases. However if it is desired that a text file be exported that can then be subsequently imported, this option should be used. The "Displayed" qualifier limits the export to only those objects that have been selected to be displayed. See section "Data Objects Filtering" below for more information.



You can use the **Import** function (select **Settings->Import Objects from txt file**) to replace the values of data objects that appear in the file you select from the Import file requestor. An import file must be *.txt and must follow a specific format. A simple two-variable import file is shown as follows:

Host Controller Interface System. Version: ESI 1.00,Sep 7 2012,15:45:03,
0000,Ma.Kp,0.2, //Motor ID1 gain
// Motor ID1 maximum command:
0000,Ma.MaxCurrentCommand,120,

The first line is required in the file, but is not well parsed by HiDS (so the above line could be used). All variables to be imported occur on individual lines and follow a common format: The leading 0000 is a variable identification, which is unused during import, so it should be four zeros. After comma separators, the variable name, its value; note the trailing comma is required on each line. The parsing of each line stops after the last comma, so comments can be added at the end of each line for improved readability and maintenance.

To save changes in non-volatile memory, select **Settings->Save Objects to non-volatile memory**, which will persist the current data object values to non-volatile RAM so that the current values will remain even after power-cycling the device.

3.2.8 Advanced tab

The **Advanced tab** provides a more complete, low-level interface to the device including access to all available data objects as well as features such as digital and analog test point configuration, digital test point capture, serial port testing, etc. The **Advanced tab** is discussed in detail in the next chapter.

3.2.9 Firmware Upgrades

The **Connection View**, which is displayed first after starting HiDS, also provides the ability to update the Firmware executing on the ESI Controller. Depending on your Controller, you can update the firmware via USB and/or CAN. Generally USB is used for most applications. To update the Controller firmware:

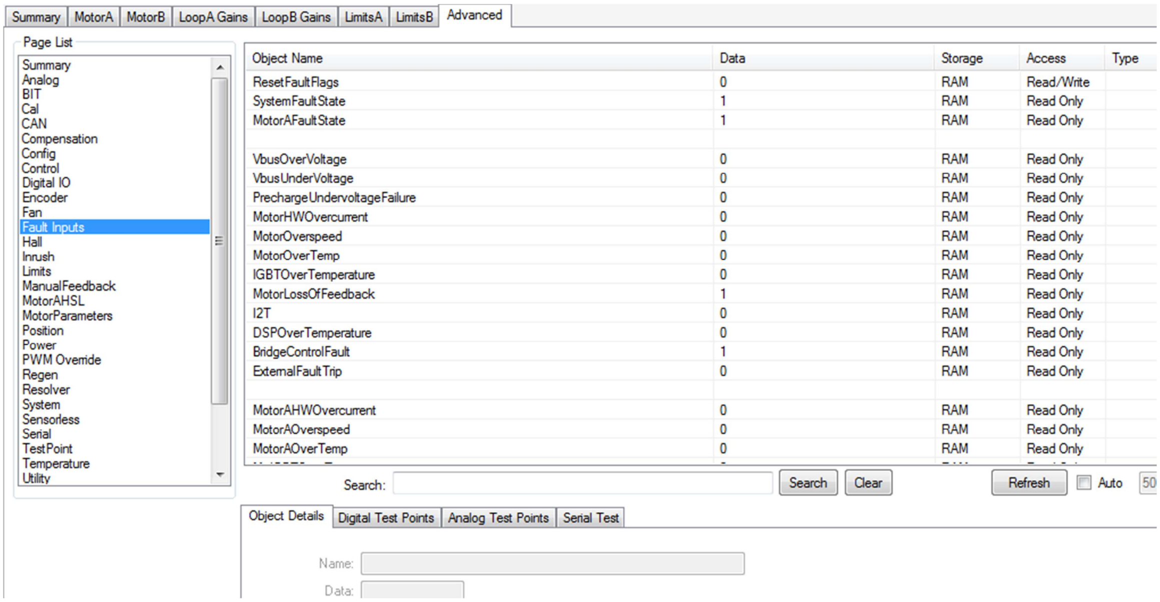
1. From the Connection View, select the USB tab.
2. Click on the [Update Firmware] button.
3. Browse to the firmware zip-file provided by ESI Motion. This file will be named ESI_<Customer name>_<ESI software number>_<version>.zip, where:'
   a. <Customer name> is probably your company name.
   b. <ESI software number> is an 800xxx number for Dragon1, 810xxx number for Dragon2, 830xxx number for the Mite family, and 820xxx number for FPGA firmware.
   c. <version> is a 3 digit number representing the version. For example, version 1.23 would be represented as 123.
4. Select the firmware zip-file, click [Open], and [Continue]. The firmware update takes 1-3 minutes depending on the PC speed and target processor.

3.3 Advanced Device Management

The **Advanced tab** provides access to a number of tools that can be used for advanced device access and management. This is provided for advanced users in non-standard applications. Note that the advanced tab can bypass some of the self-protection features of the device – care must be taken when using the **Advanced tab**.

3.3.1 Page List

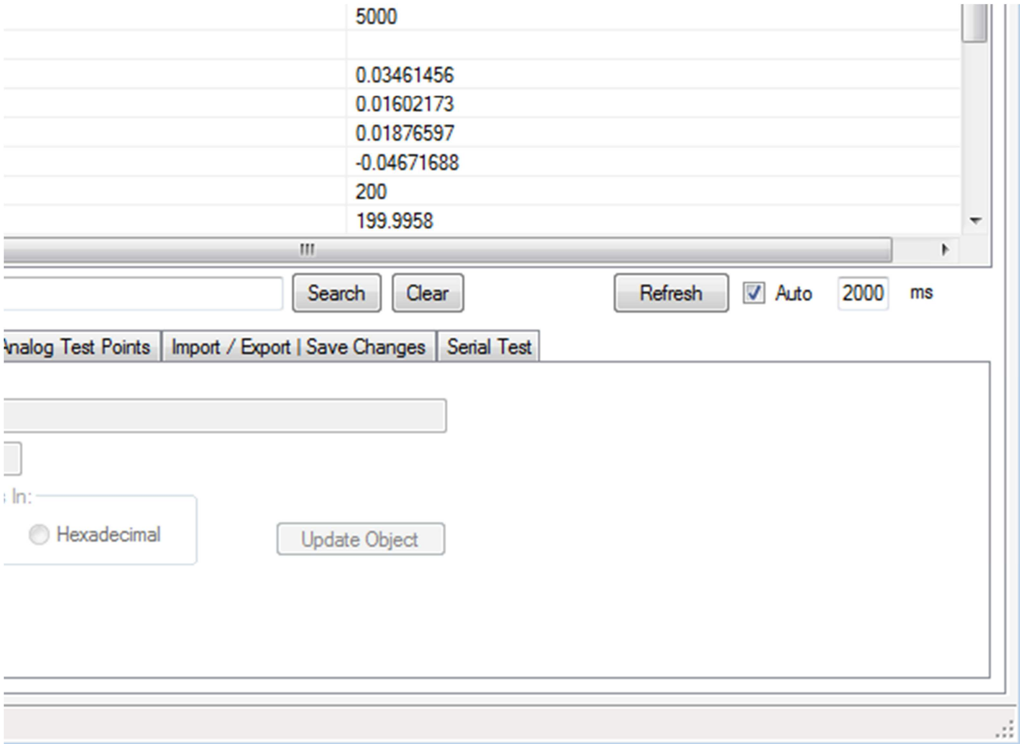
The **Page List** appears at the top, left of the **Advanced tab**. Pages provide a means of organizing data objects into distinct groups. If you click on a page from the page list area, all data objects associated with the selected page will appear in the grid at the right.



3.3.2 Data Objects List

The large grid at the top, right of the advanced tab is used to show data objects that are associated with the currently selected page or the results of a data object search. The first column shows the name of the data object and the second column (titled "data") shows the current value of the data object. Since some data object's values will change over time, you can use the **Refresh** button to reload the current values from the device.

You can also check the **Auto-Refresh** checkbox to force the application to reload the values from the device continually. Auto-Refresh requires substantial computing resources – the user may choose to slow the auto refresh by increasing the Auto Refresh rate.



3.3.3 Data Objects Storage

The third column in the Data Objects view is labeled Storage, and it indicates whether the variable is stored temporarily in RAM or can be permanently stored in non-volatile EEPROM. When **Settings->Export Displayed EEPROM Objects to txt file** is selected, only those variables that have a Storage type of EEPROM are actually saved.

3.3.4 Data Objects Access

The fourth column in the Data Objects view is labeled Access, and it indicates whether the variable is intended to be Read Only form HiDS or is intended to be Read / Write. The HiDS interface provides direct access to <u>all</u> Controller variables, so technically all variables are Read / Write. However a variable listed as Read Only is a run-time variable that will likely be over-written during normal operation. A variable listed as Read /Write is intended to be a configuration variable that will retain its settings.

3.3.5 Data Objects Filtering

The fifth and last column in the Data Objects view is labeled Type, and there are 4 variable types in the system:

1. ESI Engr (engineering): these variables are considered internal or excessively advanced as to be useful during customer monitoring and debug. They are available, but the HiDS display can be made simpler by hiding these variables – Uncheck **HiDS->Show ESI Engr Variables** to hide these variables.

2. Advanced: these variables are tagged as advanced to again limit the complexity of the system displayed. It is the intent that motor configuration and basic operation can occur with the Advanced variables hidden. Uncheck **HiDS->Show Advanced Variables** to hide these variables.

3. Required variables are those that have no descriptive type in the Type column. These are the variables that are considered fundamental to the Controller operation, and they cannot be hidden.

3.3.6 Searching for Objects

In the event that you already know all or part of the name of the data object you wish to view, you can use the **Search** feature to quickly find data points that match the text you provide. To use the search feature, begin typing the partial name of the data object in the textbox labeled “Search:” found just below the data objects list. Note that the application will continuously update the data objects list with all data objects whose name matches the text you have typed. It is not necessary to type the entire name of the data object and the search is not case sensitive. The **Clear** button can be used to clear the current search results.

When you are searching, the data objects list will show an additional column that will indicate in which page this data object is normally found. If you right-click your mouse on a data object shown in the search results, you can access the **Go to object’s page** menu item and the application will navigate to show all objects found on the same object page as the search result item.

3.3.7 User-Defined Object Page

For convenience, you can also assign data objects to a custom user-defined object page. This allows you to view your personal most commonly accessed data objects in a single location. To add a data object to your user-defined object page, you can right-click your mouse on the data object you wish to add and select the **Add to User Defined List** menu item.

To view your user-defined page, you can scroll to the bottom of the Page List and click on the **User Defined** page. You can also remove an item from your user-defined page by right-clicking your mouse and selecting the **Remove From User Defined List** menu item.

3.3.8 Editing Object Values

To edit the value of a data object, click on the data object row from the data objects list grid and then refer to the **Object Details** tab below the data objects list. From here, you can modify the value in the textbox labeled "Data:"

As described in the **Editing Parameter Values** section above, you can use the **Enter** key to commit the current value to the device or the **Esc** key to revert to the previously stored value. You can also commit the current value to the device by pressing the **Update Object** button.

3.3.9 Digital Test Points

The **Digital Test Points** tab found below the data objects list provides methods for capturing data from assigned digital test points. These features are described in detail in the **Digital Test Points** section below.

3.3.10 Analog Test Points

The **Analog Test Points** tab found below the data objects list provides methods for assigning data object values to one of the four available analog test point outputs. These features are described in detail in the **Analog Test Points** section below.

3.3.11 Serial Test

This tab provides a system for testing the serial communications and is typically used in cases where a faulty serial port, cable or device interface is suspected. Upon pressing the **Start Serial Test** button, the system will begin to send randomly generated messages to the device and will test to confirm that they are echoed back from the device without any corruption.

You can run this test for any length of time desired and the application will keep track of and display several parameters to indicate the success of the test. **Serial Test Time** will show how long the test has been running. **Successful Tests** will show a count of the number of test iterations that have succeeded without error.

The **Serial Data Errors** value shows the number of test iterations that have resulted in a serial error or data corruption. Finally, the **Serial Timeout Errors** value will indicate how many times the serial port access attempt has timed out before a response was received.

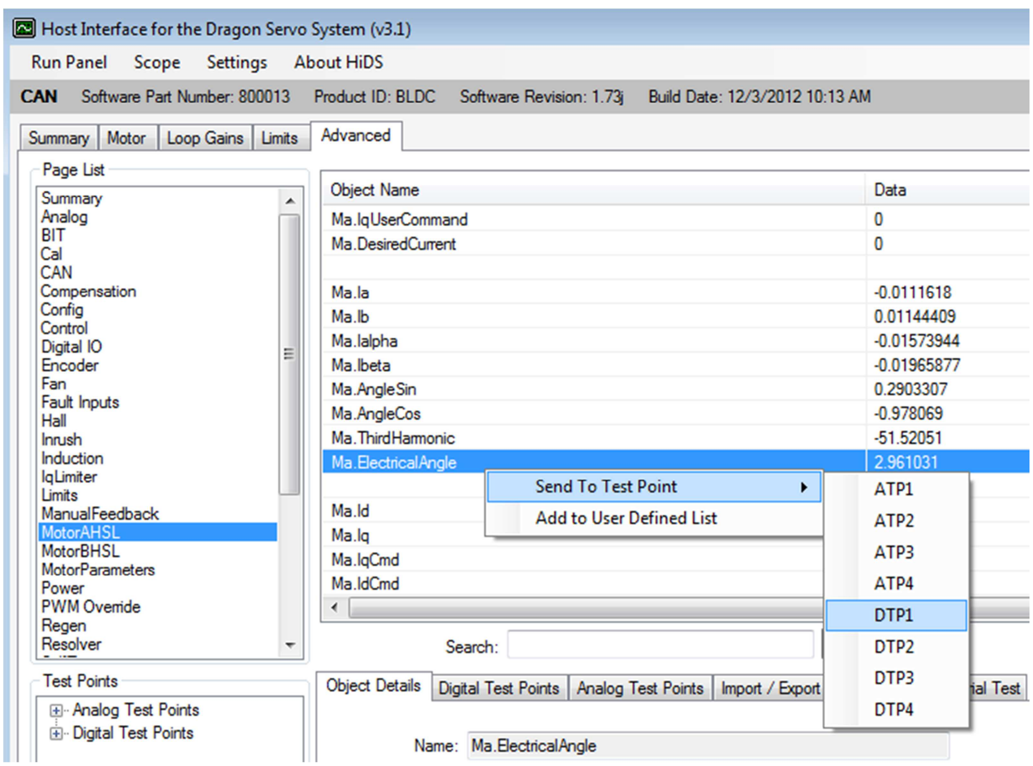
3.4 Digital Test Points

All devices are capable of capturing a buffer of up to 2048 samples of any data object in the device. Normally this data is displayed with the **Scope** feature. The user may optionally use the Digital Test Point interface to capture and download comma delimited data that can be used with spreadsheet software to review or graph.

3.4.1 Assigning Data Objects to Digital Test Points

Before capturing can be performed, you must associate from one to four data objects with an available test point. To assign a data object to a test point, you need to first make sure the data object is currently displayed in the data objects list by either clicking on the data objects' page or by searching for the data object name.

Once displayed, right-click your mouse on the data object you wish to map to a digital test point and from the menu, select **Send To Test Point** and then select one of the digital test points from the following menu (labeled "DTP1"…"DTP4").



Note assigning an object to a Digital Test Point here is the same as selecting that object in the Scope View (the Scope uses the same Digital Test Point capture mechanism).

Once you have assigned a data object to a test point, you will see it in the **Test Points** display in the lower left corner of the advanced tab as well as in the **Digital Test Points** section within the **Digital Test Points** tab. You can also remove a data object from its assignment to a digital test point by clicking the Clear button to the right of the test point desired in this area.

3.4.2 Capturing Digital Test Point Data

Test points can be captured in two modes, which is selectable using the radio buttons in the **Capture Mode** area. **Single Shot** capture mode will capture 2048 points into the capture buffer immediately when the **Start** button is pressed.

The **Capture Interval** selector specifies the amount of time between individual samples in the captured data buffer.

Once you have selected a capture interval and mode, you can begin a capture by pressing the Start button. Note that the **Points Collected** will update to reflect how many points have been collected so far and the percentage of the capture buffer that has been filled. You can interrupt or stop the capture at any time by pressing Stop.

Once you have completed a capture, you can then download the data as a comma-separated values (CSV) file by pressing the **Download Test Points** button. You can also specify whether the data contained in the capture file will be represented as **float** values or **hex** values by selecting the appropriate radio button from the **File Options** area.

3.4.3 Trigger-based Data Capture

You can also choose to capture data based on a trigger. In the section at the right labeled **Trigger Configuration**, you can specify the parameters of the trigger.

The **Channel** drop down list allows you to select which channel the data capture will trigger on. The **Slope** selection allows you to specify that the trigger should occur when the **Rising** or **Falling** edge of the trigger channel values cross the level value specified.

The **Level** value text box defines the threshold level of the trigger channel that must be passed to start the trigger. The **Position** value is a percentage value from 0% to 99% that determines where the value that caused the trigger will appear in the buffer.

For example, if the position is set to 50%, the resulting capture file will show the value of the trigger channel that matched or crossed the level value in the 1024th data point with data points 1-1024 occurring before the trigger and 1025-2048 occurring after the trigger.

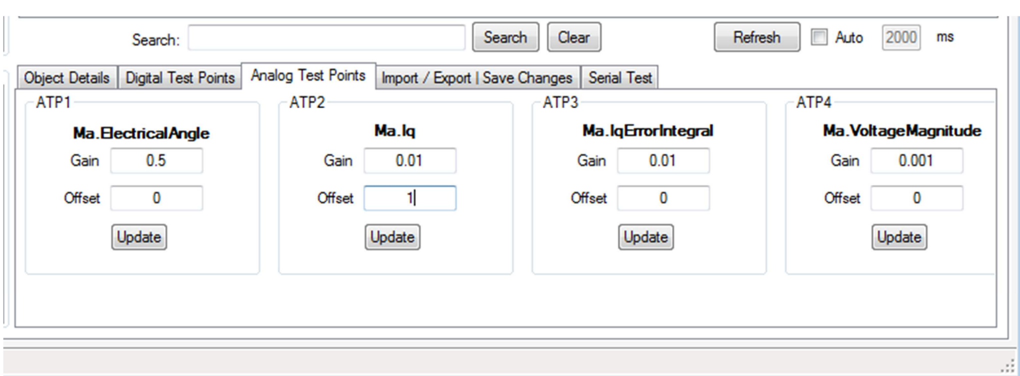
3.5 Analog Test Points

Analog test points allow for the values of data objects in the device to be accessed via the analog test point leads from the device, typically for use with external measurement and instrumentation equipment.

3.5.1 Assigning Data Objects to Analog Test Points

Any data object can be assigned to any one of the four analog test points available. To assign an analog test point, begin by locating the test point in the data objects list. Once displayed, right-click your mouse on the data object you wish to map to a digital test point and from the menu, select **Send To Test Point** and then select one of the analog test points from the following menu (labeled "ATP1"…"ATP4").

Once assigned, the **Analog Test Points** tab at the bottom of the screen will be selected and you should see your selection under the appropriate **ATP** area. From here you can also specify an **Offset** and **Gain** to apply to this test point. Once you have entered the desired offset and gain, be sure to press **Update** to apply these settings to the device.



3.6 Run Panel

The **Run Panel** can be used to view key data fields from your device using a graphical interface. You can also start and stop the motor from this interface.

The **Run Panel** is intended to show all relevant status information for the motor. The Motor, Loop Gains, and Limits tabs described above provide the configuration screens, and the Run Panel shows the operational status.

Much of the Run Panel can be customized for specific applications. The default Run Panel configuration file is "RunPanelSettings.xml", which is located in the Windows ProgramData directory, which is Windows-OS-version specific. In Windows 7, this directory is in C:\ProgramData. In this directory, there is a \ESI Motion\HiDS\{version} directory (where version is the HiDS version). This default file should not be edited.

3.6.1 Run Panel Customization

To modify a new Run Panel control:

1. Copy the RunPanelSettings.xml to another file, for example to RunPanelSettingsMyProduct.xml.

2. For each control in the Run Panel, there is an xml data structure that binds that names the control and maps the control to a product variable name as follows:

    a. Control description: <ControlDesc>Ma.AccelRPM</ControlDesc>

    b. Variable name: <ObjectName>MaVL.AccelRPMPerSec</ObjectName>

3. To bind this field to a different variable, for example the Phase-A current, Ma.Ia:

    a. Change the description name from Ma.AccelRPM to A Current

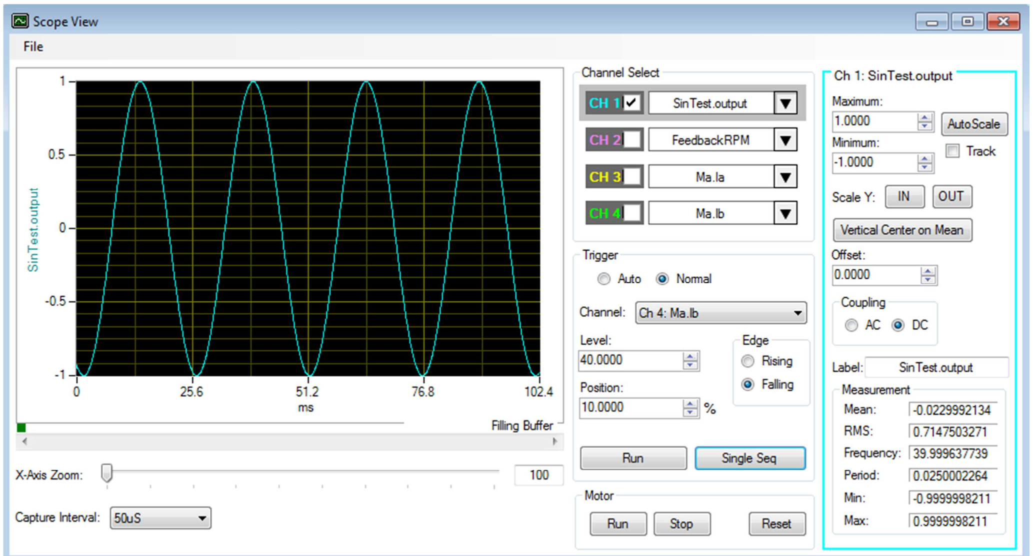
    b. Change the variable name from MaVL.AccelRPMPerSec to Ma.Ia

4. Save the xml file, and select it via the HiDS Settings menu: **Change Run Panel Config file from…**

3.7 Scope

The scope window can be opened by clicking on the **Scope** menu item at the top of the screen. The scope provides a familiar interface for accessing and viewing data objects from the device. The scope interface is divided into three vertical sections. The first section on the left contains the scope waveform display at the top and the controls for X-Axis scrolling, **X-Axis Zoom** and **X Time Base** just below.

The center section contains the **Channel Select** area at the top and the **Trigger** parameters at the bottom. The final section on the right contains detailed channel-based parameters for the currently selected channel from the **Channel Select** area.



3.7.1 Waveform Display

The waveform display area on the left will display the output from the currently active channels. The waveform will be color-coded to match the color shown in the **Channel Select** area. Depending on how many channels are selected, from one to four vertical (y-axis) scales will be presented along with a color-coded label containing the label for that channel (see **Channel Parameters** below for more details).

Below the waveform area, there is a slider labeled **X-Axis Zoom**. This can be used to zoom in on the waveform in the x-axis direction and the valid range of values is from 100% to 1000% (10x zoom). When zoomed above 100%, there will be a horizontal scroll bar directly below the waveform display that can be used to scroll horizontally to view the waveform.

The **X Time Base** drop down list can be used to modify the capture interval (from **Digital Test Points** above).

3.7.2 Channel Selection

The **Channel Select** area can be used to select digital test points and to activate or deactivate their display on the waveform view. To select a digital test point for one of the four available channels, click the down arrow icon to the right side of the channel display. This will present a dialog where you can choose a data object. The list box on the left of the dialog shows a list of object pages. After selecting an object page, the list box on the right will display data objects contained in the selected object page.

Note the user may find it easier to navigate to instead select the Scope channel via the HiDS user interface. Refer to the Digital Test Points section for Assigning Data Objects to Digital Test Points.

The check box on the left of each channel selector will toggle the visibility of that channel on the waveform display.

3.7.3 Trigger Settings

At the top of the **Trigger** section, you can select between the two trigger modes (**Auto** and **Normal**). The default mode is **Normal** and in this mode, triggering is disabled. The **Auto** mode will use the parameters below to automatically orient the waveform based on the trigger.

The **Level**, **Position**, and **Edge** parameters of the trigger function are exactly the same as the trigger parameters in the **Digital Test Points** section above *(see Trigger-based Data Capture in the Digital Test Points section above)*.

The **Stop/Start** button can be used to pause data capture and display and the **Single Seq** button can be used to capture a single data buffer only.

3.7.4 Channel Parameters

The far right side of the screen displays parameters specific to the currently selected channel from the **Channel Select** area. The currently selected channel is indicated by a medium gray bar around the channel display. The channel parameters area displays the currently selected channel number and data object name at the top of the display and the rectangular outline of the channel parameters area is also color-coded to match the channel's color.

As channels are selected for display, the **Y-Axis** scale will be automatically adjusted to contain the minimum and maximum values found in the capture buffer for that channel. The minimum and maximum Y-Axis values can be modified using the two text boxes labeled Minimum and **Maximum** and the values can be automatically determined at any time by pressing the **AutoScale** button. The **Track** checkbox will force the auto scale to occur on each capture of data buffer. This will result in a y-axis that is constantly changing but can be useful to keep the waveform visible in the display.

The **Scale Y In** and **Out** buttons can be used to adjust the **Minimum** and **Maximum Y-Axis** values in and out by 10% per click. The **Vertical Center on Mean** button will compute the mean of the waveform and then position the mean in the center of the display by adjusting the **Minimum** and **Maximum** values to be equidistant from the mean while keeping the overall vertical range the same.

The **Offset** text box can be used to vertically offset the waveform. This offset is added to the waveform values as the last step so the **Vertical Center on Mean** will not center the waveform vertically in the display if the **Offset** is non-zero.

The value entered in the **Label** text box will be displayed to the left of the waveform display to help identify that channel's vertical scale.

The **Measurement** area at the bottom shows various calculations related to the current channel when it is running including **Mean**, **RMS**, **Frequency** and **Period**.

3.8 Settings

Under the settings drop down menu at the top of the screen, the **Clear Saved Objects** command can be used to delete the cached data objects list for all previously and currently connected devices. This is typically used only if requested by technical support.

Also selectable from the settings drop down menu, the **Auto Detect Device Disconnect** option can be turned on and off. The default value is on which causes the application to periodically check for the presence of the currently connected device and perform an automatic disconnect if the device becomes unavailable (is unplugged or powered off). In the unlikely event that the application is erroneously detecting a disconnected device, this feature can be turned off.

3.9 About HiDS

The **About** menu item opens a window that shows the current application version and build number. This can be helpful if contacting technical support with HiDS-related software issues. It also displays the path to where HiDS stores user and application related data.

3.10 Simulator

The Simulator allows HiDS usage without the PC physically connected to the Controller via USB or CAN, which may be useful for training or evaluation purposes. The HiDS installation contains a simulated product based on the ESI Motion dual-axis Controller.

3.10.1 Simulator Customization

The HiDS installation contains a simulated product based on the ESI Motion dual-axis Controller. HiDS simulates the Controller objects using the file Emulator.xml, which is located in the Windows ProgramData directory, which is Windows-OS-version specific. In Windows 7, this directory is in C:\ProgramData. In this directory, there is a \ESI Motion\HiDS\{version} directory (where version is the HiDS version).

To create a product-specific version of the simulator, perform these stapes:

1. Connect HiDS to an actual ESI Motion Controller which is the Controller to be simulated.

2. In the \ESI Motion\HiDS\{version} directory, rename EmulatorDevice.xml to EmulatorDeviceOrginal.xml (back it up).

3. Find the most recent SavedDevices_x.xml file, where _x is an incremented number based on the number of different Controllers this PC has connected to.

4. Rename the most recent SavedDevices_x.xml file to EmulatorDevice.xml.

5. Select HiDS -> Clear Saved Objects.

6. Connect to HiDS Simulator.

3.11 Cycle Test

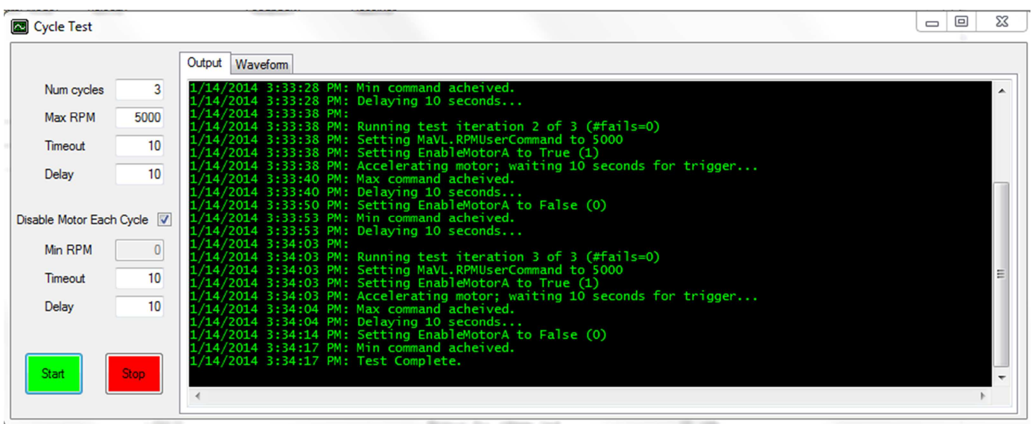
The Cycle Test view can be used to perform repetitive testing on your motor application. The Cycle Test view assumes the Controller has been properly configured for its Motor Parameters, Limits, and Loop Gains. Essentially the Controller should be properly configured to run well in your application.

Once the Controller is properly configured, Cycle Test can be view to perform a repetitive cycle of:

- Plus and Minus Current commands

- Plus or Minus Current commands with the PWMs (inverter) disabled between cycles.
- Plus and Minus Velocity commands
- Plus or Minus Velocity commands with the PWMs (inverter) disabled between cycles.
- Plus and Minus Position commands
- Plus or Minus Position commands with the PWMs (inverter) disabled between cycles.

The Cycle Test window will dynamically adjust to whether the Controller is in Torque, Velocity, or Position mode. Each text-input box has a tool-tip available for instruction; just rest your mouse over the text box to see the help. A view of the Cycle Test configured to run a Velocity cycle is shown below:



3.12 Auto Phase

The Auto Phase view can be used to automatically determine the phase relationship (offset) between the motor resolver and the motor rotor. Warning, running this test will spin the motor – typically a few revolutions in both directions.

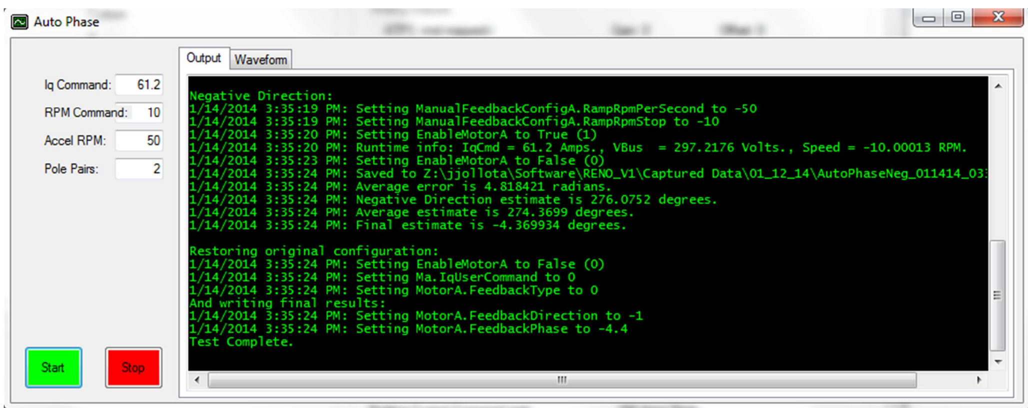
The Auto Phase view assumes the Controller has been basically configured for its Motor Parameters, Limits, and Loop Gains. Essentially the Controller should be configured from the motor data sheet as best as possible.

Once the Controller is properly configured, open Auto Phase and review the settings on the left side of the window. The motor will be driven in Manual feedback (See the Manual Feedback section below).

Manual Feedback requires a reasonably large current to force rotation – typically 20 to 30% of the maximum continuous current of the motor. The Auto Phase view will automatically set the Iq Command to 20% of the value set by Mx.MaxCurrentCommand.

The velocity set should be small compared to your application. 10RPM is a typical number. The Acceleration (Accel RPM) should also be small compared to your application, and 50 RPM is the default value.

Lastly set the check that the motor Pole Pairs value is the correct value for the motor being tested. Click Start to run the test.



The motor should spin in both directions. If it does not, check the line stating "Runtime info", which displays the applied IqCmd, and the measured VBus and RPM. For example, a VBus=0 would indicate a problem with the motor power supply connection. If the Output window displays "Motor faulted", then a run-time fault occurred during this test.

4 MOTOR TUNING

The ESI Dragon Line of modular motion control employs an industry standard current-loop, velocity-loop, and in some applications a position-loop. Each of these control loops utilizes proportional, integral, and derivative (PID) error correction to achieve the desired performance.

This section describes the procedure for tuning each control loop to match the intended application. After the tuning is completed, for applications including physical feedback (resolver or encoder) or for sensorless operation, setting the initial motor phase angle is described.

4.1 Safety First

Prior to controlling the motor in any way, the motor limits should be programmed into the ESI Controller.

1. Limit the user-current command (if in Torque mode) and the absolute currents applied to the motor:
    a. In the HiDS **Limits** tab, set the **Positive Current Command** to the specified motor maximum continuous current rating.
    b. If the negative current limit is not the same as the positive limit, in the HiDS **Limits** tab, set the **Negative Current Command** to the negative (-1 times) the specified motor maximum continuous current rating.
    c. In the HiDS **Limits** tab, set the **Over Current Fault** to 1.25 times the specified motor maximum current; this allows for brief current-spikes during normal operation. Note this initial **Over Current Fault** setting. Depending on the motor and the application, often this setting can be much higher.

2. The ESI Controller can be set to disable the motor should the motor RPM reach a maximum level.
    a. In the HiDS **Limit** tab, set the **Maximum Velocity** to the specified motor maximum speed.

For this procedure, initially limit the motor power-supply voltage to ½ of the specified motor maximum voltage. Depending on your default Vbus limits, you may have to adjust the **Maximum Bus Voltage**, the **Minimum Bus Voltage**, and the **Precharge Voltage** (all on the LimitsA tab) to be scaled down for the reduced power-supply setting.

4.2 Motor Parameters

There are some fundamental properties of the motor that the Controller needs to be configured with to properly drive the motor. All of these parameters should be available from the motor manufacturer's data sheet.

1. Inductance: In the HiDS **Motor** tab, set the **Line-to-Neutral Inductance** to ½ of the measured or specified motor Line-to-Line inductance.

2. Resistance: In the HiDS **Motor** tab, set the **Line-to-Neutral Resistance** to ½ of the measured or specified motor Line-to-Line resistance.

3. Back-EMF Constant Ke: In the HiDS **Motor** tab, set the **Line-to-Neutral Voltage Constant** to the motor Ke. Note the ESI vector controller uses Ke units of Volts-peak/RPM Line to Neutral. To convert to Line-to-Line, $Ke_{L-L} = Ke_{L-N} * \sqrt{3}$.

4. Motor Pole Pairs: In the HiDS **Motor** tab, set the **Motor Pole Pairs** to the specified motor pole pairs.

4.3 Current-Loop Tuning

4.3.1 Common Setup

These steps are common to each of the three methods below.

1. Login to the Controller using HiDS. For HiDS login and installation information, refer to the HiDS User Manual.

2. Enable the manual response feedback, which disables the physical motor velocity feedback (resolver, encoder, etc):
   a. In HiDS **Motor** tab, select the **Manual** feedback method in the **Feedback** drop-down list.

3. Enable the Controller Torque mode (by disabling velocity mode):
   a. In HiDS **Loop Gains** tab, select **Torque** method in the **Control Mode** drop-down list.

4. Disable the current-loop integral error correction, which allows an unobstructed view of the proportional gain effect:
   a. In HiDS **Loop Gains** tab, set the **Current Loop Ki** = 0.

5. Initialize the current-loop gain to a small value, to avoid possible oscillations from the start:
   a. In HiDS **Loop Gains** tab, set the **Current Loop Kp** = 1.

6. Set the user-RPM value to zero, which provides a DC-current output to the motor during the step-response tests. In the HiDS **Run Panel**, set variable **RPMUserCommand to 0.**

4.3.2 Step Response Procedure

1. Connect a current-probe to either the A (U) or B (V) phase input wires to the motor, attach the current-probe to an oscilloscope, and configure the oscilloscope to capture the current rising edge. Note the oscilloscope time scale should be approximately 100us/div.

   a. Alternately, the HiDS Scope can be used, but the resolution is limited to 25us per data point. Set channel 1 to **IqUserCommand** (for trigger), and set channel 2 to **Ma.Iq**.

2. First test the setup: During this tuning procedure the motor should not turn. In the HiDS **Run Panel**, set variable **IqUserCommand** to approximately 10% of the motor's rated constant-current value, and click on the HiDS Run Panel [Run] button. You may hear some motor hum, but the motor should not turn. Click on the HiDS Run Panel [Stop] button.

3. In the HiDS **Run Panel**, set variable **IqUserCommand** to 0, and click on the HiDS Run Panel [Run] button. Then set variable **IqUserCommand** value to approximately 10% of the motor's rated constant-current value, and observe the step response on the oscilloscope. For most applications, the goal is to achieve the classic critically damped response.

4. On the HiDS **Compensation** page, adjust **Current Loop Kp** and re-run the step response (while leaving the motor "running", set variable **IqUserCommand** to zero, and then set variable **IqUserCommand** to 10% of the motor's rated constant-current value) until a critically damped response is achieved.

4.3.2.1 Troubleshooting

1. If the motor inductance is relatively large, the motor power-supply voltage may have to be increased to achieve the characteristic step response.

2. If the initial response is an oscillation, the initial **Current Loop Kp** value of 1 may still be too large. Reduce **Current Loop Kp** to 0.1 and retry.

4.3.3 The "Ear" Procedure

If no test equipment is available, or if the environment does not allow test equipment to be easily used, the proportional gain can often be effectively determined by adjusting the gain upward until the system starts to become unstable (oscillates). Then the gain is set to ½ of that value.

Starting with a reasonably small **Current Loop Kp** value, in the HiDS **Run Panel**, set variable **IqUserCommand** to 0, and click on the HiDS Run Panel [Run] button.

Then set variable **IqUserCommand** to approximately 80% of the motor's rated constant-current value, and observe and listen to the motor system. Increase variable **Current Loop Kp** until the motor system starts to visually or audibly oscillate. At that point, set the final **Current Loop Kp** value to ½ of the value that started the oscillation.

4.3.4 Setting the Current-Loop Integral

Establishing precise integral values can be very application specific, but generally the ESI Controller current-loop integral can be set as follows:

1. In the Loop Gains tab, set the Integral Time Constant to 6ms.

2. Click the [Compute Ki] button, which will automatically set **Ma.Ki** based on the High Speed Loop Frequency.

4.4 Velocity-Loop Tuning

Tuning the velocity loop requires precise knowledge of the actual motor position. This step cannot be performed unless the motor is properly phased. This section applies to motors with physical feedbacks (resolver, encoder, etc). For sensorless velocity-loop tuning, see below.

1. Set the appropriate physical motor velocity feedback (resolver, encoder, etc):
    a. In HiDS **Motor** tab, select the **Resolver, Encoder, or Hall** feedback method in the **Feedback** drop-down list.

2. Enable the Controller Velocity mode:
    a. In HiDS **Loop Gains** tab, select **Velocity** method in the **Control Mode** drop-down list.

3. Disable the velocity-loop integral error correction, which allows an unobstructed view of the proportional gain effect:
    a. In HiDS **Loop Gains** tab, set the **Velocity Loop Ki** = 0.

4. Set the user-current value to zero, which may be non-zero from the current-loop tuning.
    a. In HiDS **Run Panel**, set the **IqUserCommand** = 0.

5. Disable velocity ramping (set to an overly large value), which would affect the gain tuning:
    a. In HiDS **VelocityLoop** page, set variable **MaVL.AccelRPMPerSec** = 100000.

6. In the HiDS **Run Panel**, set the **RPMUserCommand** value to approximately 10% of the motor's rated speed value. Note this value must

be large enough to allow the selected feedback mechanism to read above its noise floor. Typically this minimum value is 100 RPM.

7. Attach the unfiltered velocity value (measured by the selected feedback) to a HiDS digital test point.
    a. In the HiDS **Summary** page, right click on the **MaVL.RPMUserCommand** variable and select Send to Test Point and select DTP1.
    b. In the HiDS **Resolver** (or **Hall** or **Encoder** for encoder) page, right click on the **RadiansPerSecond** variable and select Send to Test Point and select DTP2.
    c. Open the HiDS oscilloscope, and configure the oscilloscope to trigger on the rising edge of the DTP1 signal.

8. In the HiDS **Run Panel,** set the **RPMUserCommand** value to 0, and click on the [Run] button; then set **RPMUserCommand** value to approximately 10% of the motor's rated speed value, and observe the step response on the oscilloscope. For most applications, the goal is to achieve a classic critically damped response.

9. On the HiDS **Loop Gains** tab, adjust the **Velocity Loop Kp** value and re-run the step response (while the motor is "running", set the **RPMUserCommand** value to 0, and then set the **RPMUserCommand** value to approximately 10% of the motor's rated constant-current value) until a critically damped response is achieved.

4.4.1 Sensorless Velocity-Loop tuning

While the above procedure fundamentally applies to sensorless, there are some key differences. When in velocity-mode, there are 2 independent regions of sensorless control – open-loop and closed-loop. Sensorless open-loop (below **MxSmo.ClosedLoopRPMThreshold**) is essentially the same as manual feedback, so there is no closed-loop velocity-loop control. Hence the **Velocity Loop Kp** and **Ki** values are irrelevant until the closed-loop region is entered.

There are then 2 ways of tuning a sensorless velocity loop:

1. Once the motor has exceeded the **MxSmo.ClosedLoopRPMThreshold** RPM, then a velocity step-response can be entered (for example if the closed-loop RPM threshold was 1000RPM, a step from 1200 to 1300 RPM could be used), and the physical-feedback method above can be used as a guide to finish the tuning. This method is problematic though, because the velocity-loop must already be tuned sufficiently in order to exceed the closed-loop RPM threshold.

2. Alternatively, set the **Velocity Loop Ki** = 0, and set the **Velocity Loop Kp** = 0.0001, and try to run the motor into the closed-loop region. With such a low Kp, you may see the motor spin up to the desired RPM and then slowly spin down (because there is insufficient gain to compensate for the RPM error). Start doubling the Velocity Kp until basic control is achieved. You can then optimize the Velocity Kp by attempting to minimize the noise on the measured Iq.

4.4.2 Setting the Velocity-Loop Integral

Establishing precise integral values can be very application specific, but generally the ESI Controller velocity-loop integral can be set as follows:

While still observing the velocity step response on the oscilloscope, adjust the **Velocity Loop Ki** until the velocity stabilizes in a time appropriate for the application.

4.5 Saving Values

In the HiDS **Settings** menu, click on the **Save Objects to EEPROM (non-volatile) memory** selection. This will save all of these parameters above into non-volatile memory.

Alternately, the resultant gain values and motor phase offset values can be saved into an importable text file, which can be imported as needed. Refer to the parameter-import section for instructions.

Loading new firmware will change saved-EEPROM variables back to the default settings, so it is recommended that an importable text file be created to insure changes can be recovered.

4.6 Comparing Current Settings with a Text File

It is recommended that all configuration changes be saved to an importable text file. This insures changes are not lost, because a firmware upgrade will change saved-EEPROM variables back to default.

To compare the current Controller configuration with the settings in a text file, in the HiDS **Settings** menu, click on the **Compare Active Objects with txt file** selection. This will compare all of the parameters in the text file with the current settings on the target. The changes will be shown on the resulting dialog, and if there are too many changes to display, all changes will be saved to the log file in the Windows ProgramData directory, which is Windows-OS-version specific. In Windows 7, this directory is in C:\ProgramData. In this directory, there is a \ESI Motion\HiDS\{version} directory (where version is the HiDS version).

5 MOTOR PHASING

Motor vector control requires precise knowledge of the actual rotor phase, so the alignment (phase-offset) between the rotor and the physical feedback (resolver, encoder, etc) must be established. Different motor manufacturers establish the resolver/encoder to rotor aligment differently, so typically the phase angle must be determined during the initial motor operation.

1. Set the appropriate physical motor velocity feedback (resolver, encoder, etc.):
   a. In HiDS **Motor** tab, select the **Resolver or Encoder** feedback method in the **Feedback** drop-down list.

2. Enable the Controller Torque mode (by disabling velocity mode):
   a. In HiDS **Loop Gains** tab, select **Torque** method in the **Control Mode** drop-down list.

3. Initialize the motor phase to zero:
   a. In HiDS **MotorA (or B)** tab, set the **Resolver (or Encoder) Offset** to 0.

4. In the HiDS **Run Panel**, set the **IqUserCommand** value to approximately 5% of the motor's rated constant-current value.

5. While still in the HiDS **Run Panel**, click on the [Run] button. If the motor spins, go to step 6. If the motor does not spin, try:
   a. In the HiDS **Motor** tab, Change the **Feedback Direction** from Forward to Reverse (or visa-versa), and re-run.
   b. Increase the **IqUserCommand** as high as 20% of the motor's rated constant-current value.
   c. In HiDS **MotorA (or B)** tab, set the **Resolver (or Encoder) Offset** to 90.

6. The objective is to change the **Resolver (or Encoder) Offset** until the motor stops spinning, regardless of the amount of IqUserCommand (torque) which is applied (which indicates the vector-control is 90° out of phase). Adjust the **Resolver (or Encoder) Offset** value and re-run. Note as you approach the zero-spin value, you may have to increase the **IqUserCommand** slightly to allow an accurate phase value to be determined.

7. When the stopping phase is properly estimated, write it down. Next add 90° to the **Resolver (or Encoder) Offset**, return to the **Run Panel**, and re-run
   a. If the current and RPM sign are the same, then this phase (stop-value plus 90°) is the correct phase to save.
   b. If the current and RPM sign are not the same, then subtract 90° from the stopping phase value found in step 6. Verify in the Run Panel that the current and RPM sign are now the same. This phase (stop minus 90°) is the correct phase to save .

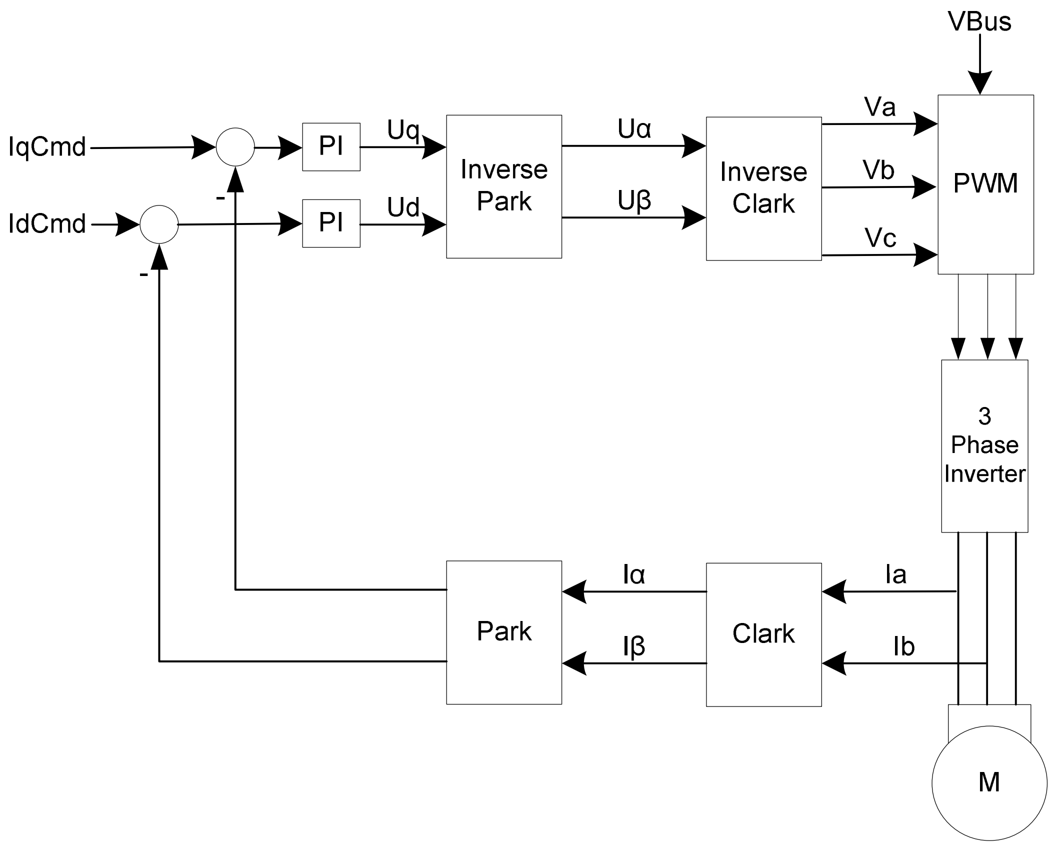
6 THEORY OF OPERATION

This section describes theory of operations of the Dragon-Series Servo Controller current-loop and velocity-loop. With the HiDS User Manual, it is the objective that the reader, with adequate knowledge of motor operations, could configure the motor and monitor its performance via HiDS.

6.1 The Current Loop

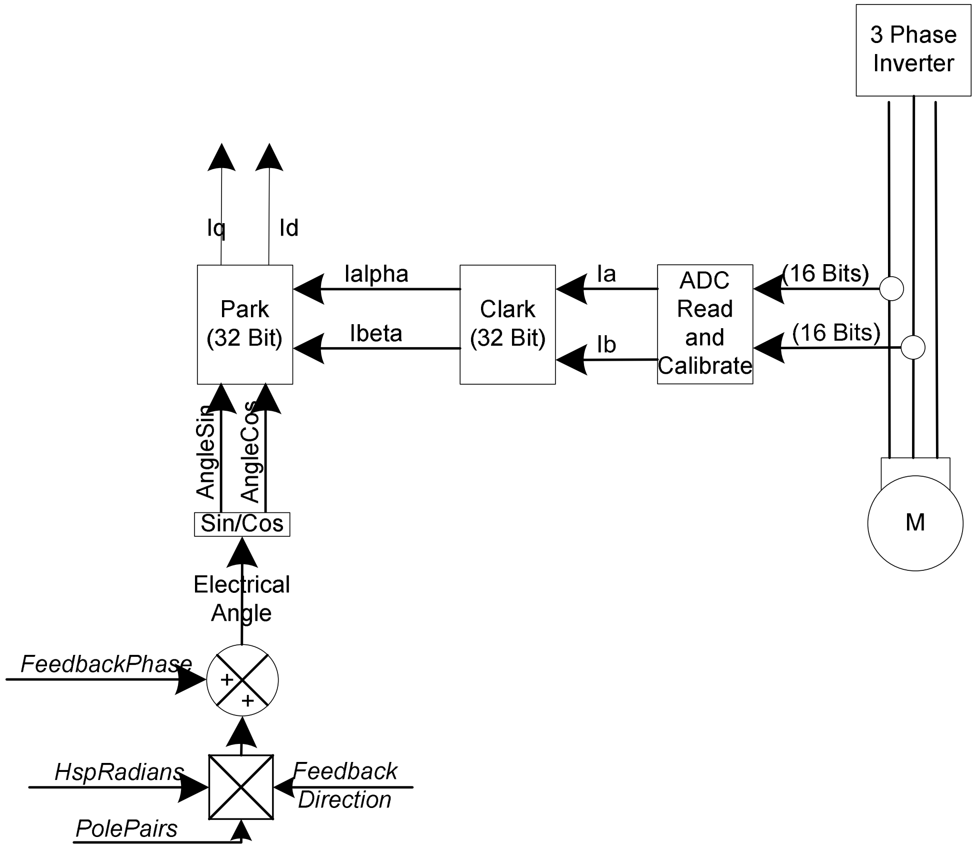
6.1.1 Clark and Park Transforms

An in-depth description of vector-control of current is not described here; the references above describe that control at varying depths. However a simplistic view of the current loop is shown below.



For simplicity, the current loop can be divided into sections below.

6.2 Clark and Park Transforms



For each motor controlled, the currents Mx.Ia and Mx.Ib (alternately the U and V phase) are measured. It is not necessary to measure Mx.Ic (W phase) as it is assumed that Ia + Ib + Ic = 0. Through 2 mathematical transformations, called the Clark transform and the Park transform, the time-varying measured currents are transformed into a time-invariant reference frame that is rotating with the electrical angle.

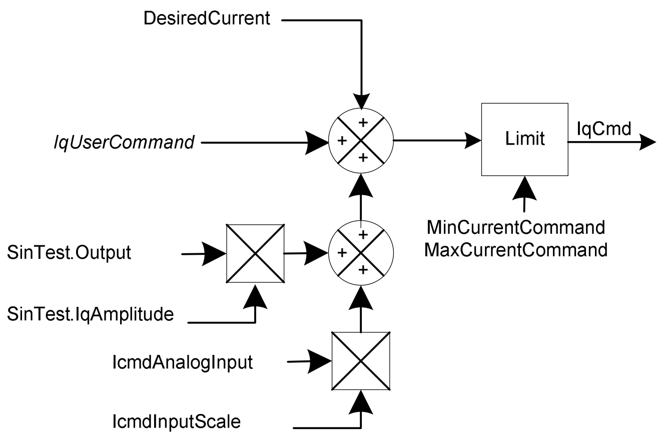
The output from the Clark transform is Mx.Ialpha and Mx.Ibeta, and in addition the Park transform requires precise knowledge of the electrical angle between the torque and flux vectors; this is accomplished via a mechanical measurement of the angle between the rotor and stator via a physical feedback mechanism such as encoder or resolver, or an estimation via a sensor-less algorithm.

To achieve the proper electrical angle, the motor parameters must be properly configured with the Motor pole pairs. In addition if a motor phase is swapped, the MotorX.FeedbackDirection can be changed (-1 or +1) to swap the sign of the feedback.

Finally, if the feedback mechanism is not aligned with the motor, the MotorX.FeedbackPhase must be entered to offset the feedback angle from the motor position. Refer to ESIMotion Motor Tuning and Phasing Procedure for details on motor phase calibration.

The output from the Park transform is the torque vector Mx.Iq and the flux vector Mx.Id, which are the measured/calculated vectors in the rotating frame to be used in compensating for error from the desired Mx.IqCmd and Mx.IdCmd.

6.2.1 IQ Command Determination



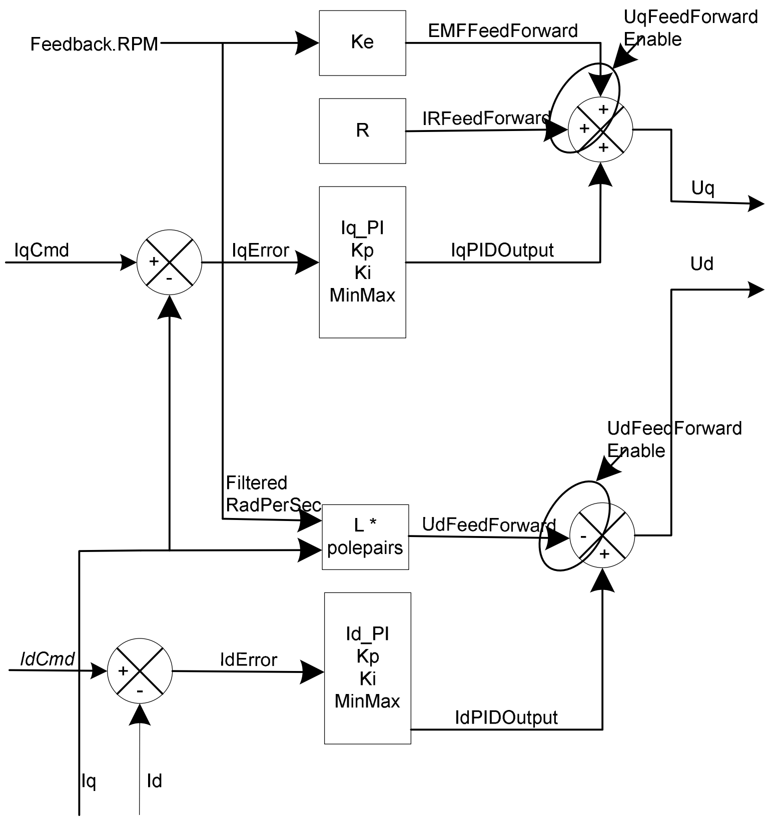
In the rotating reference frame, the resulting currents, Mx.Iq and Mx.Id, are used as feedback to compare against the input IQ command (Mx.IqCmd), which is the torque component and the ID command (Mx.IdCmd), which is the flux component. Generally Mx.IqCmd is the sole commanded current, and the Mx.IdCmd is kept at zero to maximize torque.

The input current command into the current-loop, Mx.IqCmd, is the sum of 4 possible current commands: While running in Velocity mode, the Velocity-loop output produces a Mx.DesiredCurrent input to the Current Loop. From the Utility Test page, the always running SinTest.output is a sinusoidal value between 0 and 1, with a frequency set by SinTest.frequency. The test input amplitude to the current loop can be set via the variable SinTest.iq_amplitude, which allows a sinusoidal input at the specified frequency and amplitude for debug test. Similarly, the IQCommnad input can come in via the analog input, which is scaled by the variable Mx.IcmdInputScale. Finally if running in Torque mode, the actual Mx.IqUserCommand is the current command that is input via the HiDS Run Panel, the CAN interface, or via another serial interface.

Note there is no automatic zeroing of these input variables, so for example if running in Velocity mode, you should insure the Mx.IqUserCommand is zero (or it will be summed in).

The final Mx.IqCmd output is then limited by the Configuration settings of Mx.MinCurrentCommand and Mx.MaxCurrentCommand. Note these are software limits of the current commands. Exceeding these limits simply restrains the current command input to the control system – no error occurs if these limits are exceeded. Mx.IqCmd is thus the desired IQ command to the control system, prior to error compensation.

6.2.2 IQ and ID Error Compensation



The Mx.Iq output is the torque component of the calculated Park transform from the measured Mx.Ia and Mx.Ib currents and the feedback (resolver, encoder, sensor-less) angle. Thus Mx.IqError is the error between the desired IQ command and the resultant IQ, and it is the goal to reduce this IQ error to zero.

> First the Mx.IqError is reduced via a Proportional and Integral compensation using the configurations of Mx.Kp (Gain), Mx.Ki (Integral), and Mx.IntegralMin and Mx.IntegralMax (to limit the integral error buildup). Note if Mx.AutoSetIntegralMinMax is set to 1 (true), the Mx.IntegralMin and Mx.IntegralMax are automatically set to the maximum bus voltage.

Secondly there can be feed-forward error compensation to help counter the effects of motor-back-EMF-voltage (Mx.EMFFeedForward) and the effects of IR increases (Mx.IRFeedForward). Of course these feed-forward error compensations rely on reasonably accurate configurations of the motor voltage constant MotorX.Ke and the motor phase resistance MotorX.Ohms. Typically this feed-forward is enabled (1), but it can be disabled by setting Mx.UqFeedForwardEnable = 0 (false).

The error-compensation of IQ results in an intermediate voltage of Mx.Uq.

Somewhat independent from the IQ error compensation, the ID error is reduced in a similar way. The Mx.Id output is the flux component of the calculated Park transform from the measured Mx.Ia and Mx.Ib currents and the feedback (resolver, encoder, sensor-less) angle. To maximize torque, the ID command, Mx.IdCmd, is typically set to zero. Thus Mx.IdError is the error between the desired ID command (zero) and the resultant ID, and it is the goal to reduce this ID error to zero.

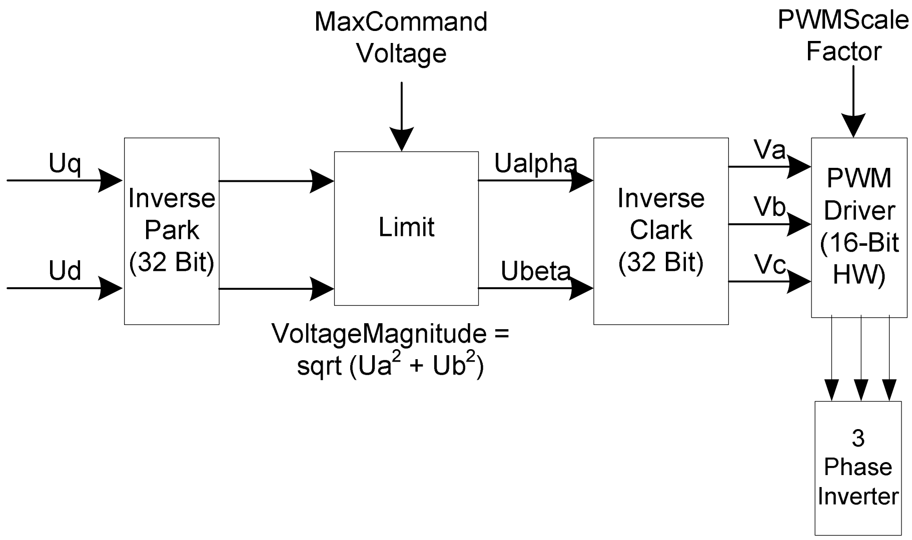
First the Mx.IdError is reduced via a Proportional and Integral compensation using the configurations of Mx.Kp (Gain), Mx.Ki (Integral), and Mx.IntegralMin and Mx.IntegralMax (to limit the integral error buildup).

Secondly there is feed-forward error compensation to help counter the effects of reactive losses (Mx.UdFeedForward) with increasing frequency. Of course this feed-forward error compensation relies on reasonably accurate configurations of the motor phase inductance MotorX.Inductance. Typically this feed-forward is enabled (1), but it can be disabled by setting Mx.UdFeedForwardEnable = 0 (false).

The error-compensation of ID results in an intermediate voltage of Mx.Ud.

Note the unit change during this error correction process. The inputs to the error correction stage are currents, yet the outputs are in units of voltage. This is the unit transition point, which prepares us for the final output of (phase) voltages.

6.2.3 The Inverse Clark and Park



The error-compensated IQ and ID result in the intermediate voltages of Mx.Uq and Mx.Ud, which are fed into the Inverse Park transform.

To limit the bounds of the error correction, the Inverse Park voltage outputs, Uaplha' and Ubeta' (not readable via HiDS), are checked against a maximum obtainable command voltage. The voltage limit is MaxCommandVoltage, which is approximately equal to the VBus (Mx.VBus) input ÷ 2 (the actual divider depends on the hardware configuration, but this is very close). The voltage checked is the Uα and Uβ voltage vector scalar, Mx.VoltageMagnitude = $\sqrt{U\alpha^2 + U\beta^2}$. The resultant Mx.Ualpha and Mx.Ubeta outputs are the Uaplha' and Ubeta' Inverse Park transform outputs multiplied by the ratio of MaxCommandVoltage ÷ Mx.VoltageMagnitude. This "saturated" condition is often a warning to an improperly controlled motor or possibly an error-condition, and the condition is flagged by Mx.Saturated = 1. The precursor to saturation is indicated by Mx.PreSaturated = 1; the Controller can often tolerate pre-saturation for some time, but the saturated condition is effectively an error state. The VBus utilization can also be monitored via Mx.VBusUtilization, which should be between 0 and 1.

The saturation-limited Mx.Ualpha and Mx.Ubeta outputs from the Inverse Park transform are inputs to the Inverse Clark transform, which produces the motor phase voltages to apply, Mx.Va, Mx.Vb, and Mx.Vc; for a 3-level bridge application, the voltages are represented by Mx.VaRaw, Mx.VbRaw, and Mx.VcRaw.

The phase voltages are then applied to the motor via a pulse-width-modulated Vbus (ADCResults.VBus).

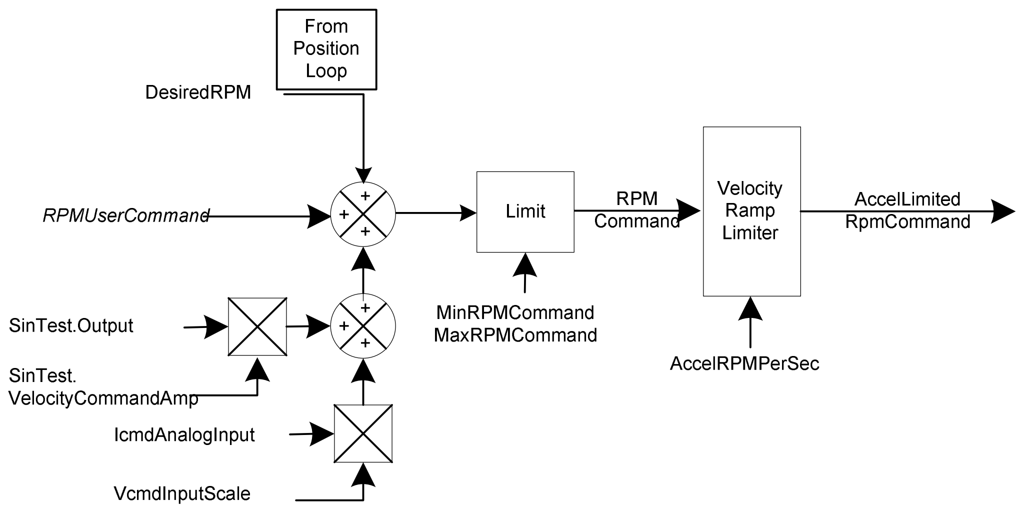
For the complete diagram, refer to Appendix B.

6.3 The Velocity Loop

The Velocity loop is effectively an independent control loop outside the Current loop, which then inputs a current (Mx.DesiredCurrent) into the Current loop.

Once again for simplicity, the velocity loop can be divided into sections below.

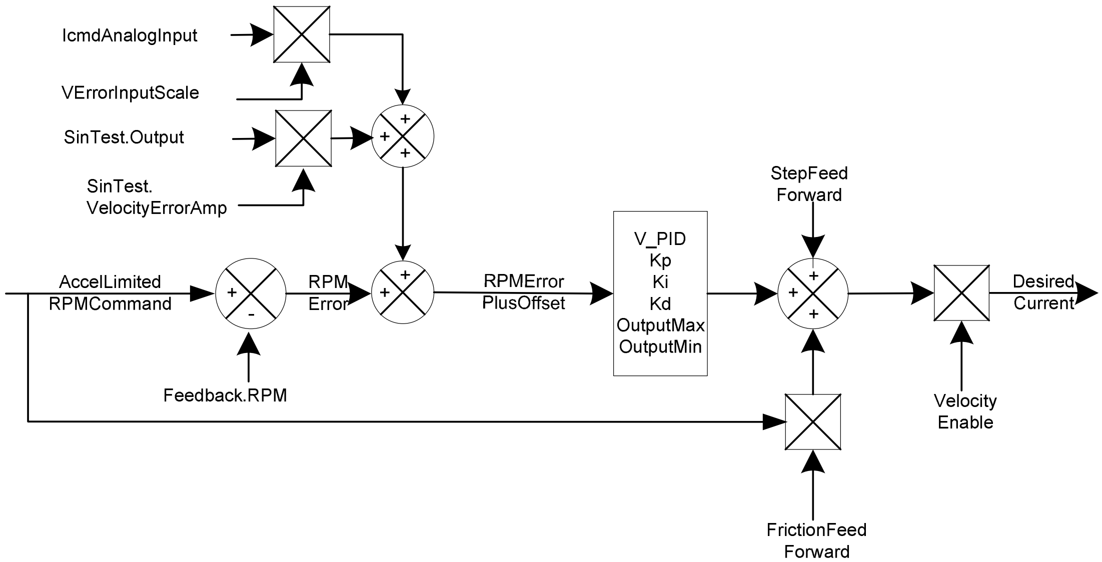
6.3.1 RPM Command Determination



The preliminary MxVL.RPMCommand output is the summed result of the Velocity-mode MxVL.RPMUserCommand (input via the CAN/Serial input or the Run Panel), the MxVL.DesiredRPM result from the Position Loop (if available), the Test input (SinTest.output * SinTest.VelocityCommandAmp), and the analog input (MxVL.VcmdInputScale * IcmdAnalogInput).

The final MxVL.AccelLimitedRPMCommand output is then limited by the user Configuration setting of MxVL.AccelRPMPerSec. Note this is a software limit of the rate of change of the velocity command (acceleration / deceleration). Exceeding this limit simply restrains the velocity command input to the control system – no error occurs if this limit is exceeded. MxVL.AccelLimitedRPMCommand is thus the desired RPM command to the control system, prior to error compensation.

6.3.2 RPM Error Compensation



MxVL.RPMError is the error between the desired RPM command and the measured velocity via the available feedback (resolver, encoder, or sensor-less), and it is the goal to reduce this RPM error to zero.

First the MxVL.RPMError is reduced via a Proportional and Integral compensation using the configurations of MxVL.VelocityKp (Gain), MxVL.VelocityKi (Integral), and MxVL.VelocityIntegralMin and MxVL.VelocityIntegralMax (to limit the integral error buildup). Note if Mx.VelocityAutoSetIntegralMinMax is set to 1 (true), the Mx.VelocityIntegralMin and Mx.VelocityIntegralMax are automatically set to the maximum current limit.

Secondly there are feed-forward error compensation to help counter the effects of friction (MxVL.FrictionFeedForward), and the effects of inertia (MxVL.StepFeedForward). Typically these feed-forwards are disabled (0), but they can be enabled by setting these values to non-zero.

Note the unit change during this error correction process. The inputs to the error correction stage are velocities, yet the outputs are in units of current. This is the unit transition point, which prepares us for the final output of (command) current.

Finally if MxVL.VelocityEnable = 0 (false), which is torque mode, the Mx.DesiredCurrent value is discarded. If MxVL.VelocityEnable = 1 (true), which is velocity mode, the Mx.DesiredCurrent value is summed into the Current loop input described above.

For the complete diagram, refer to Appendix C..

6.4 Manual Feedback

Manual Feedback is a test mode that allows simple, often unloaded, motor operation. Manual Feedback is useful to troubleshoot physical feedback (encoder, resolver, hall, etc.) problems, or other basic motor-control problems. When Manual Feedback is selected, the "measured" feedback angle is automatically calculated based on the RampRpmPerSecond (acceleration) value. Manual Feedback is often used unloaded (without significant mass connected to the motor) because, in this mode, there is no physical feedback to determine the necessary phase-voltage changes to maintain motor control.

Manual Feedback essentially provides an AC voltage to the motor phases with the frequency determined by ManualFeedbackConfigA.RPM. To use Manual Feedback, the following procedure can be used:

1. In the HiDS MotorA tab, select the Manual feedback method in the Feedback dropdown list.

2. In HiDS Loop Gains tab, select Torque method in the Control Mode drop-down list.

3. In HiDS Advanced tab, ManualFeedback page, set variables ManualFeedback ConfigA.RPM and ManualFeedbackConfigA.RampEnable both to 0.

4. In HiDS Advanced tab, ManualFeedback page, set variable ManualFeedback ConfigA.RampRpmStop to the desired final RPM. This RPM must be "easy" to achieve for the motor, and is often less than 20% of the rated motor speed.

5. In HiDS Advanced tab, ManualFeedback page set variable ManualFeedback ConfigA.RampRpmPerSecond to the desired acceleration. This acceleration must also be "easy" to achieve for the motor. A typical value is 500 RPM per second.

6. In the HiDS Run Panel, set the IqUserCommand to 25% of the rated motor current. This value must be large enough to force commutation of the motor, essentially without feedback.

7. In the HiDS Run Panel, click [Run]. Note there may be some small movement in the motor as the DC-current may align the rotor to stator magnets.

8. In HiDS Advanced tab, ManualFeedback page set variable ManualFeedback ConfigA.RampEnable to 1. The motor should begin to spin from 0 to Manual FeedbackConfigA.RampRpmStop using an acceleration of ManualFeedback ConfigA.RampRpmPerSecond. If the

motor fails to spin, click [Stop] on the Run Panel and try increasing the IqUserCommand to as much as 50% of the rated motor current.

7 APPENDIX A: HIDS VARIABLE GLOSSARY

The data-types and bounds shown below should be considered when setting and reading a HiDS variable; however all Controller variables are exchanged with HiDS as single-precision floating-point numbers, so care should be given to insure variables are configured within their defined bounds or only using the acceptable values.

All MotorA variables descriptions below apply to Motor B and Motor C variables for multiple-axis configurations.

7.1 Summary

Description: All variables shown on this page are copies of variables from other pages. This page only congregates commonly viewed variables. The descriptions of each of these are shown below.

7.2 Analog

Variable name: **Various**
Summary: The raw measured values for various currents, voltages, and temperatures in the system. Note there may be more variables shown on this page than are actually measured within the particular controller.
HiDS location: Shown on Analog page in Advanced tab.
Description: Read Only. This page is unlikely to be viewed during normal operation, but it might be useful when trying to determine if a Controller is missing an external connection, or if a Controller may have an internal failure. The various internal fixed voltages are shown (+5V, 3.3V, 1.9V, 24V, etc.), and the raw measured values for all other analog readings.

Individual Descriptions:
Vbus: Motor Power measurement in Volts. On Dragon1-based Controllers, this measurement may only be available while the controller is enabled.

D24VMon, D5VAMon, D3_3VAMon, D2_5VAMon, and D2_5VARef:
These are internal DC voltages, in Volts, that are expected to be close to the numeric named values.

ADCResults.MaVa, MaVb, and MaVc:
These are the motor phase A, B, and C (U, V, and W respectively) voltages in Volts.

ADCResults.MaIa, MaIb, and MaIc:

These are the intermediate motor phase A, B, and C (U, V, and W respectively) currents in Amps, pre-calibration. See Mx.Ia, Mx.Ib, and Mx.Ic on the MotorXHSL page for the calibrated values.

Mx.Ibus: Motor power current measured in Amps.

Mx. IcmdAnalogInput: Voltage measured, in Volts, of the analog command input. In a control mode, the signal may be used to give the Controller a torque or velocity command. In test mode, the signal may be used to inject a test signal into the system.

Mx.BrakeI: The measured current, in Amps, of the current supplied to the motor brake.

DSPTemp: The measured temperature, in degrees C, of the internal Digital Signal Processor.

MaxCommandVoltage:
This is the dynamically calculated maximum voltage, in Volts, that is available to commutate the motor. Once Mx.VoltageMagnitude exceeds the MaxCommandVoltage, the current-loop is referred to as saturated and is no longer able to produce the desired current, velocity, or position.

7.3 BIT (Built In Test)

The BIT variables are shown in groups as follows:
<measurement name> BIT.enable indicates whether the BIT is enabled(1) or disabled(0).
<measurement name> BIT.limit indicates the failure threshold, which is set to the units of the measurement being tested; read/write.
<measurement name> BIT.current_count indicates the number of failed tests; note this count is cumulative, not consecutive; read only.
<measurement name> BIT.max_count indicates the maximum number of failed tests. This variable is not used for a pass or fail determination, but can be used to indicate the BIT may be close to failure; read only.
<measurement name> BIT.trip_count indicatesthe number of failed counts to show fault; note this count is cumulative, not consecutive. Unless otherwise indicated, each test occurs every 1 millisecond; read only.
<measurement name> BIT.WarningEnable indicates whether the BIT warning check is enabled(1) or disabled(0). Warnings have no effect on run-time, and are typically reported via CAN or RS422 to the upper-layer control system.
<measurement name> BIT.WarningLimit indicates the warning threshold, which is set to the units of the measurement being tested; read/write.
<measurement name> BIT.WarningCount indicates the number of warning-exceeded tests; note this count is cumulative, not consecutive; read only.

The measurement limits can be configured in the [Limits] tab, or they can be changed by adjusting the <measurement name> BIT.limit variable located on the BIT page in the Advanced Tab:

Variable name: **VbusOvervoltageBIT and VbusUndervoltageBIT**
Description: Read / Write. Measures in Volts the motor bus voltage /motor power supply voltage for an over/under voltage condition.
Tab name: On the [Limits] configuration tab, these variables are referred to as the Min Bus Voltage and Max Bus Voltage.
Units/Bounds: Volts. The over-voltage limit is set to the maximum allowable voltage of the motor, or the Controller, whichever is lower. The under-voltage is typically set lower than any operating voltage possible, and is typically used to disable the Controller should motor-voltage be disconnected or lost.

Variable name: **MaIGBTTemperatureBIT**
Description: Read / Write. Each IGBT (insulated-gate bipolar transistor) has an individual thermistor for temperature monitoring, and this variable tests the maximum values of all IGBT thermistors, in degrees C.
Tab name: On the [Limits] configuration tab, these variables are referred to as the IGBT Temperature.
See also: MbIGBTTemperatureBIT is the Motor B equivalent.
Units/Bounds: Degrees C. The limits depend on the Controller electronic configuration.

Variable name: **MaMotorTempBit**
Description: Read / Write. If the motor has an available thermistor for temperature monitoring, this variable can be used to report a warning or failure fault, and is reported in degrees C.
Tab name: On the [Limits] configuration tab, this variable is referred to as the Motor Temperature Limit.
See also: MbMotorTempBit is the Motor B equivalent.
Units/Bounds: Degrees C. Set to the maximum temperature of the motor.

Variable name: **DSPTemperatureBIT**
Description: Read / Write. The internal DSP (Digital Signal Processor) has an internal thermistor for temperature monitoring, in degrees C.
Tab name: On the [Limits] configuration tab, this variable is referred to as the DSP Temperature Limit.
Units/Bounds: Degrees C. Typically set to 90º

Variable name: **MaOverspeedPos**
Description: Read / Write. Each motor has a maximum safe operating speed, and this variable will disable the motor if the RPM-threshold is exceeded.
Tab name: On the [Limits] configuration tab, this variable is referred to as the Positive Velocity Limit.
Units/Bounds: RPM. Set to the maximum speed of the motor.

Variable name: **MaLossOfFeedback**
Description: Read / Write. For resolver feedbacks, this test measures the average RMS voltage of the Resolver Sine and Cosine inputs, and will disable the motor should a feedback be disconnected. For a Serial Encoder,

this BIT is overloaded to check for SerialEncoderData.Error to equal True (1) or False (0).

Tab name: On the [Limits] configuration tab, this variable is referred to as the Motor Feedback Limit.

Units/Bounds: Volts-RMS. For Dragon1-resolver, this is typically 2V. For Dragon2-resolver, this is typically 0.5V. For Serial-Encoders, this is typically 0.5 (just between 1 and 0).

Variable name: **I2T**

Description: Read / Write. I2T (read I-squared-T) is an estimation of the energy content in current transient conditions. Because a motor can often handle short current transients in excess of rated currents, this test can help protect against motor overheating or damage due to excess current transients.

Tab name: On the [Limits] configuration tab, this variable is referred to as the I2T Limit.

Units/Bounds: $Amps^2$ * Degrees-C; unbounded.

For each fault test above, there are warning checks that can be independently enabled or disabled. The equivalent warning variable names are prefaced with "Warning".

7.4 Cal

Variable name: **Various**

Summary: The current-calibration values, as well as any other customer or application specific calibrations.

HiDS location: Shown on Cal page in Advanced tab.

Description: Read Only. Besides ESI-internal debug variables, this page is only contains customer-relevant variables should there be customer or application specific calibrations. Please refer to the customer-specific HiDS addendum for these variables.

7.5 CAN

Variable name: **CanAddresses.ChannelNumber**

Summary: The default channel number of the CAN HiDS interface.

HiDS location: Shown on CAN page in Advanced tab.

Description: Read / Write. For Controllers using CAN communication for HiDS, this is the channel number shown on the initial connection view when HiDS first starts. For an application that has 2 or more Controllers connected to the same PC, this channel number can be assigned uniquely to each Controller, which allows the PC to address each Controller differently. To change this value, one should insure the USB interface works first, because making a mistake here may require USB connectivity to correct. To take effect, change the channel number (to 1 for instance),

	select Settings->Save Objects to EEPROM, and reset the Controller.
Units/Bounds:	Integer, the valid values are 0 to 15.

Variable name:	**CanAddresses.BitRate**
Summary:	The default bit-rate of the CAN communication bus.
HiDS location:	Shown on CAN page in Advanced tab.
Description:	Read / Write. For Controllers using CAN communication for HiDS or control, the Controller will ship with a default bit-rate (often 1Mbps). Should another value be desired, this variable can be changed to 500, 250, or 100 (Kbps). Note should an incorrect value be entered and saved here, the only way to recover would be to login via USB and fix the value.
Units/Bounds:	Baud /bits per second, the valid values are 100000, 250000, 500000, and 1000000.

Variable name:	**CanAddresses.IncommingHids / OutgoingHids**
Summary:	The default addresses of the CAN HiDS interface.
HiDS location:	Shown on CAN page in Advanced tab.
Description:	Read Only. For Controllers using CAN communication for HiDS, these are the CAN addresses of the HiDS connection. All ESI Motion Controllers ship using 1536 (0x600) for incoming and 1552 (0x610) for outgoing. The actual addresses used are (1536 + CanAddresses.ChannelNumber) for incoming and (1552 + CanAddresses.ChannelNumber) for outgoing. If another CAN device is one a shared bus, and if an address conflict occurs, then CanAddresses.ChannelNumber can be changed to offset the HiDS addresses.
Units/Bounds:	Integer, the valid values are 1536 (0x600) to 1551 (0x60F) for incoming messages and 1552 (0x610) to 1567 (0x61F) for outgoing messages.

Variable name:	**CanNetworkUsedForHids**
Summary:	Indicates which CAN-bus HiDS is currently connected to.
HiDS location:	Shown on CAN page in Advanced tab.
Description:	Read Only. For Controllers that support multiple CAN busses, the variable indicates which CAN bus is in use for HiDS.
Units/Bounds:	Integer, 1 indicates CAN-A, 2 indicates CAN-B, or 3 for CAN-C, if available.

Variable name:	**CanControlInterfaceEnabled**
Summary:	Enables (1) or disables (0) the external, non-HiDS, CAN command interface.
HiDS location:	Shown on CAN page in Advanced tab.
Description:	Read / Write. For Controllers using CAN communication for control, this variable can enable or disable that control interface. Note in order to use HiDS for motor control, it is likely that the external CAN control interface must be disabled.
Units/Bounds:	Boolean, the valid values are 0 or 1.

Variable name:	**CANCommandMsgID**
Summary:	The message ID of the CAN command packet.

HiDS location: Shown on CAN page in Advanced tab.
Description: Read / Write. For Controllers using CAN communication for control, this variable sets the address / message ID of the incoming CAN command packet.
Units/Bounds: Integer, the valid values are 1 to 2047 (11 bits).

Variable name: **CANFeedbackMsgEnable**
Summary: A Boolean; enables (1) the CAN status message or disables (0) it.
HiDS location: Shown on CAN page in Advanced tab.
Description: Read / Write. For Controllers using CAN communication for status, this variable enables or disables that message. Setting this variable to 0 disables the message and 1 enables it.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **CANFeedbackMsgID**
Summary: The message ID of the CAN feedback/status packet.
HiDS location: Shown on CAN page in Advanced tab.
Description: Read / Write. For Controllers using CAN communication for status, this variable sets the address / message ID of the outgoing CAN feedback / command packet.
Units/Bounds: Integer, the valid values are 1 to 2047 (11 bits).

Variable name: **CANFeedbackMsgInterval**
Summary: The message ID of the CAN feedback/status packet.
HiDS location: Shown on CAN page in Advanced tab.
Description: Read / Write. For Controllers using CAN communication for status, this variable sets the interval in milliseconds between CAN status packet transmissions.
Units/Bounds: Milliseconds, the valid values are 1 to 65535.

7.6 Compensation

7.6.1 Current Loop

Variable name: **Mx.Kp**
Summary: Motor X current-loop gain compensation.
HiDS location: Shown on Loop Gains tab in Current Loop frame.
Description: Read / Write. Used to adjust the Proportional Gain component for reducing the error between the Iq command (Mx.IqCmd) and Iq actual (Mx.Iq), and in addition reducing the error between the Id command (Mx.IdCmd), which is typically zero and Id actual (Mx.Id).
See also: Mb.Kp is the Motor B equivalent.
Units/Bounds: Volts per Amp, positive values only.

Variable name: **Mx.Ki**
Summary: Motor X current-loop integral compensation.
HiDS location: Shown on Loop Gains tab in Current Loop frame.
Description: Read / Write. Used to adjust the Integral Gain component for reducing the error between the Iq command (Mx.IqCmd) and Iq actual (Mx.Iq),

	and in addition reducing the error between the Id command (Mx.IdCmd), which is typically zero and Id actual (Mx.Id).
See also:	Mb.Ki is the Motor B equivalent.
Units/Bounds:	Unit-less, positive values only.

Variable name:	**Mx.IqErrorIntegral, Mx.IdErrorIntegral**
Summary:	Motor X current-loop IQ and ID current integral values.
HiDS location:	Shown on Compensation page in Advanced tab.
Description:	Read Only. Displays the integral value of the loop.
See also:	Mb.IqErrorIntegral and Mb.IdErrorIntegral are the Motor B equivalents.
Units/Bounds:	Volts, bounded by Mx.IntegralMin and Mx.IntegralMax.

Variable name:	**Mx.IntegralMin / Mx.IntegralMax**
Summary:	Motor X current-loop integral compensation minimum and maximum limits.
HiDS location:	Shown on Loop Gains tab in Current Loop frame.
Description:	Read / Write. Integral Gain compensation is a slower moving compensation, and under certain conditions is subject to error buildup. These settings limit the integral value to the limits specified. Note these are automatically set to the maximum output limits of the loop if variable Mx.AutoSetIntegralMinMax is set to true (1).
See also:	Mb.IntegralMin and Mb.IntegralMax are the Motor B equivalents.
Units/Bounds:	Volts, Mx.IntegralMax should be positive; Mx.IntegralMin should be negative. The bounds are application specific, but should be less than the motor-bus voltage available.

Variable name:	**Mx.AutoSetIntegralMinMax**
Summary:	Auto-sets Motor X current-loop integral compensation minimum and maximum limits.
HiDS location:	Shown on Compensation page in Advanced tab.
Description:	Read / Write. If 1 (true), automatically sets the Mx.IntegralMax to the voltage set by the VbusOvervoltageBIT.limit variable, and sets the Mx.IntegralMin to the negative of the VbusOvervoltageBIT.limit variable.
See also:	Mb.AutoSetIntegralMinMax and Mb.AutoSetIntegralMinMax are the Motor B equivalents.
Units/Bounds:	Boolean, the valid values are 0 or 1.

Variable name:	**Mx.IdAutoSetToIqGainValues**
Summary:	Auto-sets Motor X ID current-loop compensation variables to the IQ compensation settings.
HiDS location:	Shown on Compensation page in Advanced tab.
Description:	Read / Write. If 1 (true), automatically sets the Mx.IdKp and Mx.IdKi to the Mx.Kp and Mx.Ki settings, which is the most common.
See also:	Mb. IdAutoSetToIqGainValues is the Motor B equivalent.
Units/Bounds:	Boolean, the valid values are 0 or 1.

7.6.2 Velocity Loop

Variable name: **Mx.VelocityKp**

Summary: Motor X velocity-loop gain compensation.
HiDS location: Shown on Loop Gains tab in Velocity Loop frame.
Description: Read / Write. Used to adjust the Proportional Gain component for reducing the error between the acceleration-limited Velocity command (MxVL.AccelLimitedRPMCommand) and actual measured velocity (either ResolverARpm or EncoderA.Rpm depending on the actual feedback).
Units/Bounds: Amps per RPM, positive values only.

Variable name: **Mx.VelocityKi**
Summary: Motor X velocity-loop integral compensation.
HiDS location: Shown on Loop Gains tab in Velocity Loop frame.
Description: Read / Write. Used to adjust the Integral Gain component for reducing the error between the acceleration-limited Velocity command (MxVL.AccelLimitedRPMCommand) and actual measured velocity (either ResolverARpm or EncoderA.Rpm depending on the actual feedback).
Units/Bounds: Unit-less, positive values only.

Variable name: **Mx.VelocityKd**
Summary: Motor X velocity-loop derivative compensation.
HiDS location: Shown on Loop Gains tab in Velocity Loop frame.
Description: Read / Write. Used to adjust the Derivative Gain component for reducing the error between the acceleration-limited Velocity command (MxVL.AccelLimitedRPMCommand) and actual measured velocity (either ResolverARpm or EncoderA.Rpm depending on the actual feedback). Note the derivative term is typically zero as derivative compensation can often lead to loop instability.
Units/Bounds: Amps, positive values only.

Variable name: **Mx.VelocityErrorIntegral**
Summary: Motor X velocity-loop current integral value.
HiDS location: Shown on Compensation page in Advanced tab.
Description: Read Only. Displays the integral value of the loop.
Units/Bounds: Amps, bounded by Mx.VelocityIntegralMin and Mx.VelocityIntegralMax.

Variable name: **Mx.VelocityIntegralMin / Mx.VelocityIntegralMax**
Summary: Motor X velocity-loop integral compensation minimum and maximum limits.
HiDS location: Shown on Loop Gains tab in Velocity Loop frame.
Description: Read / Write. Integral Gain compensation is a slower moving compensation, and under certain conditions is subject to error buildup. These settings limit the integral value to the limits specified.
Note these are automatically set to the maximum output limits of the loop if variable Mx.VelocityAutoSetIntegralMinMax is set to true (1).
Units/Bounds: Amps, Mx.VelocityIntegralMax should be positive; Mx.VelocityIntegralMin should be negative. The bounds are application specific, but should be less than the over-current value (Mx.HardwareOvercurrent).

Variable name: **Mx.VelocityAutoSetIntegralMinMax**
Summary: Auto-sets Motor X velocity-loop integral compensation minimum and maximum limits.
HiDS location: Shown on Compensation page in Advanced tab.
Description: Read / Write. If 1 (true), automatically sets the Mx.VelocityIntegralMax to the amperage set by the Mx.HardwareOvercurrent variable, and sets the Mx.VelocityIntegralMin to the negative of the Mx.HardwareOvercurrent variable.
Units/Bounds: Boolean, the valid values are 0 or 1.

7.6.3 Position Loop

Variable name: **Mx.PositionKp**
Summary: Motor X Position-loop gain compensation.
HiDS location: Shown on Loop Gains tab in Position Loop frame.
Description: Read / Write. Used to adjust the Proportional Gain component for reducing the error between the acceleration-limited Position command (MxPL. AccelLimitedRadiansCommand) and actual measured Position (MotorXAbsolutePosition).
Units/Bounds: RPM per Radian, positive values only.

Variable name: **Mx.PositionKi**
Summary: Motor X Position-loop integral compensation.
HiDS location: Shown on Loop Gains tab in Position Loop frame.
Description: Read / Write. Used to adjust the Integral Gain component for reducing the error between the acceleration-limited Position command (MxPL.AccelLimitedRadiansCommand) and actual measured Position (MotorXAbsolutePosition).
Units/Bounds: Unit-less, positive values only.

Variable name: **Mx.PositionKd**
Summary: Motor X Position-loop derivative compensation.
HiDS location: Shown on Loop Gains tab in Position Loop frame.
Description: Read / Write. Used to adjust the Derivative Gain component for reducing the error between the acceleration-limited Position command (MxPL.AccelLimitedRadiansCommand) and actual measured Position (MotorXAbsolutePosition). Note the derivative term is typically zero as derivative compensation can often lead to loop instability.
Units/Bounds: RPM, positive values only.

Variable name: **Mx. RadiansErrorIntegral**
Summary: Motor X Position-loop current integral value.
HiDS location: Shown on Compensation page in Advanced tab.
Description: Read Only. Displays the integral value of the loop.
Units/Bounds: Amps, bounded by Mx.PositionIntegralMin and Mx.PositionIntegralMax.

Variable name: **Mx.PositionIntegralMin / Mx.PositionIntegralMax**
Summary: Motor X Position-loop integral compensation minimum and maximum limits.
HiDS location: Shown on Loop Gains tab in Position Loop frame.

Description: Read / Write. Integral Gain compensation is a slower moving compensation, and under certain conditions is subject to error buildup. These settings limit the integral value to the limits specified.
Note these are automatically set to the maximum output limits of the loop if variable Mx.PositionAutoSetIntegralMinMax is set to true (1).
Units/Bounds: RPM, Mx.PositionIntegralMax should be positive; Mx.PositionIntegralMin should be negative. The bounds are application specific, but should be less than the over-speed value (MaOverspeedPos.limit).

Variable name: **Mx.PositionAutoSetIntegralMinMax**
Summary: Auto-sets Motor X position-loop integral compensation minimum and maximum limits.
HiDS location: Shown on Compensation page in Advanced tab.
Description: Read / Write. If 1 (true), automatically sets the Mx.PositionIntegralMax to the RPM set by the MaOverspeedPos.limit variable, and sets the MaOverspeedPos.limit to the negative of the Mx.HardwareOvercurrent variable.
Units/Bounds: Boolean, the valid values are 0 or 1.

7.6.4 Sensorless Velocity Loop

Variable name: **MxSmo.VelocityKp**, **MxSmo.VelocityKi**
Summary: Velocity-loop proportional and integral compensations for sensorless operation.
HiDS location: shown only in the Advanced Compensation page
Description: Read / Write. These variables are analogous to their Mx.VelocityKp and Mx.VelocityKi counterparts, but because of the increased latencies associated with a sensorless feedback, these gains are often lower than their physical feedback counterparts. These 2 values are used from 0 RPM until MaSmo.ClosedLoopRPMThreshold RPM is reached.
Units/Bounds: Kp is Amps per RPM; Ki is unit-less, positive values only.

Variable name: **MxSmo.VelocityErrorIntegral**
Summary: Motor X Velocity-loop current integral value for the sensorless velocity loop.
HiDS location: Shown on Compensation page in Advanced tab.
Description: Read Only. Displays the integral value of the loop.
Units/Bounds: Amps, bounded by MxSmo.VelocityIntegralMin and MxSmo.VelocityIntegralMax.

Variable name: **MxSmo.VelocityIntegralMin / MxSmo.VelocityIntegralMax**
Summary: Motor X velocity-loop integral compensation minimum and maximum limits for the sensorless velocity loop.
HiDS location: Shown on Loop Gains tab in Velocity Loop frame.
Description: Read / Write. Integral Gain compensation is a slower moving compensation, and under certain conditions is subject to error buildup. These settings limit the integral value to the limits specified.

Units/Bounds: Amps, MxSmo.VelocityIntegralMax should be positive;

MxSmo.VelocityIntegralMin should be negative. The bounds are application specific, but should be less than the over-current value (Mx.HardwareOvercurrent).

7.7 Config

Variable name:	**RevertSettingsToFactoryDefault**
Summary:	Reverts all EEPROM values to the factory defaults.
HiDS location:	Shown on Config page in Advanced tab.
Description:	Read / Write. Will reset the Controller and will reset all stored parameters to the original factory default. It is highly recommended that all Controller settings be exported prior to executing this, as there all customer-changes will be lost.
Units/Bounds:	Boolean, the valid values are 0 or 1.

7.8 Control

Variable name:	**Various**
Summary:	Motor A and Motor B state machine variables and brake controls.
HiDS location:	Shown on Control page in Advanced tab.
Description:	Read Only. Typically only ESI-internal debug variables

7.9 Digital IO

Variable name:	**Various**
Summary:	Shows the logic levels of the digital inputs and allows HiDS control of the digital outputs.
HiDS location:	Shown on Digital IO page in Advanced tab.
Description:	Read Only for Digital Inputs; Read / Write for Digital Outputs. Besides ESI-internal debug variables, this page is only contains customer-relevant variables should there be customer or application specific calibrations. Please refer to the customer-specific HiDS addendum for these variables.

7.10 Encoder

Variable name:	**EncoderX.Degrees**
Summary:	Motor X Encoder position in degrees.
HiDS location:	Shown on Encoder page in Advanced tab.
Description:	Read Only. Shows the motor position in degrees, normalized to 0 to 360º.
Units/Bounds:	Degrees, the valid values are 0 to 360.

Variable name:	**EncoderX.Radians**

Summary: Motor X Encoder position in Radians.
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds: Radians, the valid values are 0 to 2π.

Variable name: **EncoderX.RPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds: RPM, unbounded.

Variable name: **EncoderX.FilteredRPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if encoder feedback is selected).
Units/Bounds: RPM, unbounded.

Variable name: **EncoderX.RadiansPerSecond**
Summary: Motor X velocity in Radians per second
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds: Radians per second, unbounded.

Variable name: **EncoderX.RadiansSummed**
Summary: Motor X Encoder accumulated position in Radians.
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read Only. Unless explicitly cleared, this variable shows the total accumulated motor position in radians, since power on.
Units/Bounds: Radians, unbounded.

Variable name: **EnableEncoderPower**
Summary: A Boolean; enables (1) the +5V switchable output to the Interface connector; 0 (False) disables it.
HiDS location: Shown on Encoder page in Advanced tab.
Description: Read / Write. For Controllers supporting a +5V switchable output, this variable allows HiDS control of that switch.
Units/Bounds: Boolean, the valid values are 0 or 1.

7.11 Fan

Note not all controllers support the Fan feature. The Fan state is updated every 1 second.

Variable name: **Fan.Hysteresis**
Summary: Sets the temperature hysteresis to turn the fan off.
HiDS location: Shown on Fan page in Advanced tab.

Description: Read / Write The Fan is turned off when the filtered MaIGBTTemp is less than (Fan.OnDegreesC - Fan.Hysteresis).
Units/Bounds: Degrees C, unbounded.

Variable name: **Fan.OnDegreesC**
Summary: Sets the temperature threshold to turn on or turn off the fan.
HiDS location: Shown on Fan page in Advanced tab.
Description: Read / Write The Fan is turned on when the filtered MaIGBTTemp is greater than Fan.OnDegreesC. The fan is turned off when the filtered MaIGBTTemp is less than (Fan.OnDegreesC - Fan.Hysteresis).
Units/Bounds: Degrees C, unbounded.

Variable name: **Fan.State**
Summary: Indicates the on/off state of the fan.
HiDS location: Shown on Fan page in Advanced tab.
Description: Read Only. False (0) indicates the fan is off. 1 (True) indicates the fan is on.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **Fan.FaultState**
Summary: Indicates the unlatched fault state current-limit-flag of the fan drive circuitry.
HiDS location: Shown on Fan page in Advanced tab.
Description: Read Only. False (0) indicates the fan driver is operating normally. 1 (True) indicates the fan driver is in an over-current state.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **Fan.FaultLatch**
Summary: Indicates the latched fault state current-limit-flag of the fan drive circuitry.
HiDS location: Shown on Fan page in Advanced tab.
Description: Read Only. False (0) indicates no fan driver fault has occurred since the last clear. 1 (True) indicates a fan driver fault has occurred since the last clear.
Units/Bounds: Boolean, the valid values are 0 or 1.

7.12 Fault Inputs

For each of the BITs (Built In Tests), a latched fault bit can occur. If the Run Panel shows a fault, or if the motor fails to run, these fault flags will indicate what failure has occurred.

If after clicking [Reset] on the Run Panel, and one or more fault flags fail to clear, then this is a persistent failure condition that must be resolved before continuing.

All of the following variables are located on the Fault Inputs page in the Advanced Tab:

Variable name: **ResetFaultFlags**
Description: Read / Write. Setting this value to 1 (true) is equivalent to clicking the [Reset] button on the Run Panel. Note this variable is automatically reset to 0 after faults are reset.

Variable name: **MotorHWOvercurrent**
Description: Read only. One indicates one or more of the hardware over-current tests have failed. See the specific motor fault flags below for clarification.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorOverspeed**
Description: Read only. One indicates one or more of the over-speed tests have failed. See the specific motor fault flags below for clarification.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorOverTemp**
Description: Read only. One indicates one or more of the motor over-temperature tests have failed. See the specific motor fault flags below for clarification.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **IGBTOverTemperature**
Description: Read only. One indicates one or more of the IGBT over-temperature tests have failed. See the specific motor fault flags below for clarification.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **VbusOverVoltage**
Description: Read only. One indicates the VbusOvervoltageBIT failed.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **VbusUnderVoltage**
Description: Read only. One indicates the VbusUndervoltageBIT failed.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **ManualFeedbackConfigFailure**
Description: Read only. If the Inrush feature is enabled (see Inrush below), this failure indicates that during motor startup, the measured Vbus was less than the Inrush.VbusOnThreshold threshold. This failure often indicates a disconnected or zero-voltage VBus (motor power supply)
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **I2T**
Description: Read only. One indicates the I2T test failed.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **BridgeControlFault**
Description: Read only. One indicates one or more IGBTs reported an internal error. This condition could result from extreme motor conditions, but more

likely indicates a hardware problem.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **SystemFaultState**
Description: Read only. One simply indicates one or more of the described fault flags is 1 (true).
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorXHWOvercurrent**
Description: Read only. One indicates the measured current exceeded the value set by Mx.HardwareOvercurrent. While the warning-level is configurable via the MaOvercurrent BIT, the fault is controlled by hardware and is not configurable via the BIT page.
See also: MotorBHWOvercurrent is the Motor B equivalent.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorXOverspeed**
Description: Read only. One indicates the MaOverspeedPos BIT failed.
See also: MotorBOverspeed is the Motor B equivalent.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorXOverTemp**
Description: Read only. One indicates the MaMotorTempBit BIT failed.
See also: MotorBOverTemp is the Motor B equivalent.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MaIGBTOverTemperature**
Description: Read only. One indicates the MaIGBTTemperatureBIT BIT failed.
See also: MbIGBTOverTemperatureis the Motor B equivalent.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MotorXLossOfFeedback**
Description: Read only. One indicates the MaLossOfFeedback BIT failed.
Units/Bounds: Boolean, the valid values are 0 or 1.

7.13 FPGA (Dragon2 and Hyperion only)

Variable name: **FPGABuildDay/Hour/Minute/Year**
Summary: Displays the FPGA build "revision".
HiDS location: Shown on FPGA page in Advanced tab.
Description: Read Only. Shows the build date of the current FPGA "firmware".
Units/Bounds: Date.

7.14 Hall

Variable name: **HallX.Degrees**

Summary:	Motor X Hall position in degrees.
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Shows the motor position in degrees, normalized to 0 to 360º.
Units/Bounds:	Degrees, the valid values are 0 to 360.

Variable name:	**HallX.Radians**
Summary:	Motor X Hall position in Radians.
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds:	Radians, the valid values are 0 to 2π.

Variable name:	**HallX.RPM**
Summary:	Motor X velocity in RPM
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds:	RPM, unbounded.

Variable name:	**HallX.FilteredRPM**
Summary:	Motor X velocity in RPM
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if Hall feedback is selected).
Units/Bounds:	RPM, unbounded.

Variable name:	**HallX.RadiansPerSecond**
Summary:	Motor X velocity in Radians per second
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds:	Radians per second, unbounded.

Variable name:	**HallX.RadiansSummed**
Summary:	Motor X Hall accumulated position in Radians.
HiDS location:	Shown on Hall page in Advanced tab.
Description:	Read Only. Unless explicitly cleared, this variable shows the total accumulated motor position in radians, since power on.
Units/Bounds:	Radians, unbounded.

7.15 Inrush

This page sets the values used to test Vbus in-rush during motor startup, and is configured internally by ESI Motion.

7.16 Limits

Many of the measurement limits can be configured in the [Limits] tab, but the Motor B limits are not shown there. To change the motor B limits, adjust the Motor B variables shown on the Limits page in the Advanced Tab.

Variable name: **Mx.MinCurrentCommand and Mx.MaxCurrentCommand**
Summary: The minimum/maximum current command provided to the motor. The current-loop output is bound by these limits.
HiDS location: Shown on Limits tab.
Description: Read / Write. Used to bound the current command into the current-loop. If running in Torque mode, these limits simply restrict the current command. If running in Velocity or Position modes, if the output from the Velocity loop reaches these limits, then velocity (or position) loop integrals may build up, which may lead to an over-current fault condition.
See also: Mb.MinCurrentCommand and Mb.MaxCurrentCommand are the Motor B equivalents.
Tab name: On the [Limits] configuration tab, these variables are referred to as Positive and Negative Current Limit.
Units/Bounds: Amps, Mx.MaxCurrentCommand should be positive; Mx.MinCurrentCommand should be negative. The bounds are application specific, but should be less than the over-current value (Mx.HardwareOvercurrent).

Variable name: **Mx.HardwareOvercurrent**
Summary: The maximum measured current allowed before declaring a fault condition.
HiDS location: Shown on Limits tab.
Description: Read / Write. Used to detect the over-current fault condition. If this limit is reached, even for a brief moment, a fault is declared and the motor is disabled.
See also: Mb.HardwareOvercurrent is the Motor B equivalent.
Units/Bounds: Amps, the maximum current rating is defined by the product specification.

7.17 Manual Feedback

For a description of the use of Manual Feedback, refer to the Theory of Operations section within this document.

Variable name: **ManualFeedbackX.Degrees**
Summary: Motor X Manual Feedback position in degrees.
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read Only. Shows the motor position in degrees, normalized to 0 to 360º.
Units/Bounds: Degrees, the valid values are 0 to 360.

Variable name: **ManualFeedbackX.Radians**
Summary: Motor X Manual Feedback position in Radians.

HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds: Radians, the valid values are 0 to 2π.

Variable name: **ManualFeedbackX.RPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds: RPM, unbounded.

Variable name: **ManualFeedbackX.FilteredRPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if manual feedback is selected).
Units/Bounds: RPM, unbounded.

Variable name: **ManualFeedbackX.RadiansPerSec**
Summary: Motor X velocity in Radians per second
HiDS location: Shown on ManualFeedback page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds: Radians per second, unbounded.

Variable name: **ManualFeedbackConfigX.RampRpmPerSecond**
Summary: Configures the Motor X Manual Feedback acceleration.
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read / Write. Used in conjunction with ManualFeedbackConfigX.RPM and ManualFeedbackConfigX.RampRpmStop, the RampRpmPerSecond configures the RPM acceleration from ManualFeedbackConfigX.RPM to ManualFeedbackConfigX.RampRpmStop. Note this value is auto-set to **MxVL.AccelRPMPerSec** if **AutoSetManualFeedbackParameters** is set to true (1). This allows the standard Run Panel to be used in Manual Feedback.
Units/Bounds: RPM per second, unbounded.

Variable name: **ManualFeedbackConfigX.RampRpmStop**
Summary: Configures the Motor X Manual Feedback RPM to stop accelerating to.
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read / Write. Used in conjunction with ManualFeedbackConfigX. RampRpmPerSecond and ManualFeedbackConfigX.RampRpmStop, the RampRpmStop configures end velocity to accelerate to. Note this value is auto-set to **MxVL.RPMUserCommand** if **AutoSetManualFeedbackParameters** is set to true (1). This allows the standard Run Panel to be used in Manual Feedback.
Units/Bounds: RPM, unbounded.

Variable name: **ManualFeedbackConfigX.RampEnable**

Summary: Enables (1) or disables (0) the Motor X Manual Feedback acceleration.
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read / Write. Enables or disables the acceleration from ManualFeedbackConfigX.RPM to ManualFeedbackConfigX.RampRpmStop.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **ManualFeedbackConfigX.RPM**
Summary: Configures or configures the Motor X Manual Feedback RPM value.
HiDS location: Shown on ManualFeedback in Advanced tab.
Description: Read / Write. When RampEnable = 0, this variable configures the starting manual feedback RPM value. When RampEnable = 1, this variable shows the current manual feedback RPM value. Often configured (written) to zero.
Units/Bounds: RPM, unbounded.

7.18 MotorAHSL, MotorBHSL

Variable name: **Various**
Summary: Shows the operational status of the vector-control Current loop.
HiDS location: Shown on MotorAHSL page in Advanced tab.
Description: Mostly Read Only. These variables are described in the Theory of Operations section within this document.

7.19 MotorParameters

All of the relevant motor parameters can be configured in the [Motor] tab.

Variable name: **MotorX.Inductance**
Description: Read / Write. This inductance is the inductance per phase, so if measured / supplied motor inductance is measured line-to-line, then the internal value is ½ the line-to-line value.
Units/Bounds: Henries, positive only.

Variable name: **MotorX.Ohms**
Description: Read / Write. The units of resistance shown on the [Motor] tab are Line to Neutral Ohms. This resistance is the resistance per phase, so if measured / supplied motor resistance is measured line-to-line, then the internal value is ½ the line-to-line value.
Units/Bounds: Ohms, positive only.

Variable name: **MotorX.Ke**
Description: Read / Write. Also known as the voltage constant or back-EMF constant, the units of the Motor voltage constant, Ke, are Line-to-Neutral Volts/RPM. The conversion between Line-to-Line: L-L V/KRPM = L-N V/RPM * 1000 * √3

Tab name: On the [Motor] configuration tab, this variable is referred to as the Line-To-Line Voltage Constant.
Units/Bounds: Volts per RPM, positive only.

Variable name: **MotorX.PolePairs**
Description: Read / Write. Note this is the pole pairs – the actual number of motor poles ÷ 2.
Units/Bounds: Integer, positive only.

Variable name: **MotorX.FeedbackPhase**
Description: Read / Write. For proper vector control of a motor, the resolver shaft must be aligned with the motor shaft (usually in manufacturing), or else a phase offset must be entered here. The FeedbackPhase is the electrical angle offset.
Tab name: On the [Motor] configuration tab, this variable is referred to as the Resolver Offset or Encoder Offset.
Units/Bounds: Degrees, valid from -360º to 360º.

Variable name: **MotorX.FeedbackDirection**
Description: Read / Write. Should a motor phase wire be swapped or a resolver sine/cosine swap occur, this variable can compensate; the valid values are 1 (normal) or -1 (reversed).
Units/Bounds: Signed multiplier, the valid values are -1 or 1.

Variable name: **MotorX.ResolverSpeed**
Description: Read / Write. If the resolver indicates multiple rotations of the motor, during a single actual motor rotation, this value can be set to that multiple.
Units/Bounds: Integer, positive only.

Variable name: **MotorX.FeedbackType**
Description: Read / Write. This variable would normally be changed via the [Motor] tab feedback dropdown list. However if this variable is included in an imported text file, the values to use are:
0=Resolver
1=Quadrature encoder
2=Manual
3=Sensorless feedback
4= Hall
5= Serial encoder

7.20 Position

Variable name: **MotorXPositionEnable**
Description: Read / Write. This variable would normally be changed via the [Loop Gains] tab Control Mode dropdown list. However if this variable is included in an imported text file, the values to use are: 0=Velocity mode and 1 = Position Mode.
Units/Bounds: Boolean, 0=Velocity mode and 1 = Position Mode.

Variable name: **MxPL.MinRadiansCommand**
Description: Read / Write. MxPL.MinRadiansCommand limits the lower value of the input to the position loop.
Units/Bounds: Radians, unbounded.

Variable name: **MxPL.MaxRadiansCommand**
Description: Read / Write. MxPL.MaxRadiansCommand limits the upper value of the input to the position loop.
Units/Bounds: Radians, unbounded.

Variable name: **MotorXAbsolutePosition**
Description: Read Only. For resolver and encoder feedbacks, the MotorXAbsolutePosition equals the MxPL.GearRatio times the ResolverXRadiansSummed or EncoderA.RadiansSummed respectively.
Units/Bounds: Radians, unbounded.

Variable name: **MxPL.RadiansUserCommand**
Description: Read / Write. MxPL.RadiansUserCommand sets the desired motor position in Radians. This value is summed with (Mx.Icmd * MxPL.PcmdInputScale) to produce MxPL.RadiansCommand.
Units/Bounds: Radians, unbounded.

Variable name: **MxPL.RadiansCommand**
Description: Read Only. MxPL.RadiansCommand is the final positional input into the position loop, and is the sum of MxPL.RadiansUserCommand and (Mx. IcmdAnalogInput* MxPL.PcmdInputScale).
Units/Bounds: Radians, unbounded.

Variable name: **MxPL.AccelLimitedRadiansCommand**
Description: Read Only. For a step-response input to MxPL.RadiansUserCommand, the MxPL.AccelLimitedRadiansCommand variable is the resulting positional action is limited by positional acceleration value setting variable MxPL.AccelRadiansPerSec.
Units/Bounds: Radians, unbounded.

Variable name: **MxPL.DesiredRPM**
Description: Read Only. MxPL.DesiredRPM is the output RPM from the position-loop, which is an input RPM command to the velocity-loop.
Units/Bounds: RPM, bounded by MxPL.MinRPMCommand and MxPL.MaxRPMCommand.

Variable name: **MxPL.AccelRadiansPerSec**
Description: Read / Write. For a step-response input to MxPL.RadiansUserCommand, the MxPL.AccelRadiansPerSec positional acceleration variable limits the resulting positional action, which is indicated by MxPL.AccelLimitedRadiansCommand.
Units/Bounds: Radians per second, positive only.

Variable name: **MxPL.PcmdInputScale**
Description: Read / Write. MxPL.PcmdInputScale sets the scale used to multiply the

	Mx. IcmdAnalogInputinput to produce a position input to the position loop based on the analog voltage input provided. When Mx. IcmdAnalogInputis unused, this value is set to zero. This value is summed with MxPL.RadiansUserCommand to produce MxPL.RadiansCommand.
Units/Bounds:	Radians per volt, unbounded.

Variable name:	**MxPL.RadiansError**
Description:	Read Only. MxPL.RadiansError indicates the positional error. MxPL.RadiansError = MxPL.AccelLimitedRadiansCommand - MxPL.AbsolutePosition.
Units/Bounds:	Radians, unbounded.

Variable name:	**MxPL.GearRatio**
Description:	Read / Write. For resolver and encoder feedbacks, the MxPL.GearRatio specifies the gear ratio of the motor system, if one exists.
Units/Bounds:	Integer, positive only.

7.21 Power

The Controller captures real-time phase voltage and current measurements in order to estimate the real, reactive, and apparent components of the power applied.

Variable name:	**MxPower.PhaseAIRms**
Summary:	Motor X, phase A current RMS.
HiDS location:	Shown on Power page in Advanced tab.
Description:	Read Only. The Phase A current.
Units/Bounds:	Amps-RMS, bounded only by the current-limit of the controller.

Variable name:	**MxPower.PhaseAVRms**
Summary:	Motor X, phase A voltage RMS.
HiDS location:	Shown on Power page in Advanced tab.
Description:	Read Only. The Phase A voltage.
Units/Bounds:	Volts-RMS, bounded only by the voltage-limit of the controller.

Variable name:	**MxPower.PhaseAReal**
Summary:	Motor X, phase A real power.
HiDS location:	Shown on Power page in Advanced tab.
Description:	Read Only. The Phase A real-component of power is the average of the product of Mx.Va * Mx.Ia.
Units/Bounds:	Watts, bounded by Mx.Va and Mx.Ia.

Variable name:	**MxPower.PhaseAApparent**
Summary:	Motor X, phase A apparent power.
HiDS location:	Shown on Power page in Advanced tab.
Description:	Read Only. The Phase A apparent power is the product of MxPower.PhaseAIRms * MxPower.PhaseAVRms in Watts.
Units/Bounds:	Watts, bounded by MxPower.PhaseAIRms and

MxPower.PhaseAVRms.

Variable name: **MxPower.PhaseAReactive**
Summary: Motor X, phase A reactive power.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. The Phase A reactive power is calculated indirectly as the square-root of ($MxPower.PhaseAApparent^2$ - $MxPower.PhaseAReal^2$).
Units/Bounds: Watts, bounded by MxPower. PhaseAApparent and MxPower. PhaseAReal.

Variable name: **MxPower.Real**
Summary: Motor X, total real power.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. It is assumed each phase-power is equal, so MxPower.Real = 3 * MxPower.PhaseAReal.
Units/Bounds: Watts, bounded by MxPower.Real.

Variable name: **MxPower.Apparent**
Summary: Motor X, total apparent power.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. It is assumed each phase-power is equal, so MxPower.Apparent = 3 * MxPower.PhaseAApparent.
Units/Bounds: Watts, bounded by MxPower.Apparent.

Variable name: **MxPower.Reactive**
Summary: Motor X, total reactive power.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. It is assumed each phase-power is equal, so MxPower.Reactive = 3 * MxPower.PhaseAReactive.
Units/Bounds: Watts, bounded by MxPower.Reactive.

Variable name: **MxPower.PF**
Summary: Motor X, total power factor.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. MxPower.PF = MxPower.Real / MxPower.Apparent.
Units/Bounds: Unit-less, bounded by MxPower.Real and MxPower.Apparent.

Variable name: **MxPower.PFDegrees**
Summary: Motor X, power factor angle.
HiDS location: Shown on Power page in Advanced tab.
Description: Read Only. MxPower.PFDegrees = arc-cos(MxPower.RF) in degrees.
Units/Bounds: Degrees, 0-360.

7.22 Regen

Not all Controllers support the Regen feature. Refer to your Controller's specifications. If supported, the Regen feature will usually be enabled by default, and the Regen voltage threshold can be set with the HiDS Limits Tab.

Variable name: **Regen.Enable**
Summary: Enables (1) or Disables (0) the Regen feature.
HiDS location: Shown on Regen page in Advanced tab.
Description: Read / Write. Enables or disables the Regen feature.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **Regen.State**
Summary: Indicates whether the Regen switch is active (1) or not (0).
HiDS location: Shown on Regen page in Advanced tab.
Description: Read Only. Indicates whether the Regen switch is active (1) or not (0).
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **Regen.OnThreshold**
Summary: Sets the voltage threshold at which to enable the Regen switch.
HiDS location: Shown on Regen page in Advanced tab.
Description: Read / Write Only. Sets the voltage limit, which when exceeded, the Rgen switch is enabled, and energy will be dissipated by the Regen resistor.
Units/Bounds: Voltage, bounded by the voltage limitation of the Controller.

Variable name: **Regen.MaxOn_ms**
Summary: Sets the maximum on and off duration of the regen switch.
HiDS location: Shown on Regen page in Advanced tab.
Description: Read / Write Only. In order to protect the Regen resistor, limit the Regen on (and off) time to 'MaxOn_ms' milliseconds.
Units/Bounds: Milliseconds, 0 to 65535.

7.23 Resolver

Variable name: **ResolverX.Degrees**
Summary: Motor X Resolver position in degrees.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the motor position in degrees, normalized to 0 to 360º.
Units/Bounds: Degrees, the valid values are 0 to 360.

Variable name: **ResolverX.Radians**
Summary: Motor X Resolver position in Radians.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds: Radians, the valid values are 0 to 2π.

Variable name: **ResolverX.RPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds: RPM, unbounded.

Variable name: **ResolverX.FilteredRPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if Resolver feedback is selected).
Units/Bounds: RPM, unbounded.

Variable name: **ResolverX.RadiansPerSecond**
Summary: Motor X velocity in Radians per second
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds: Radians per second, unbounded.

Variable name: **ResolverX.RadiansSummed**
Summary: Motor X Resolver accumulated position in Radians.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Unless explicitly cleared, this variable shows the total accumulated motor position in radians, since power on.
Units/Bounds: Radians, unbounded.

Variable name: **ResolverXFeedbackRms**
Summary: Motor X Resolver measured voltage RMS.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. The ResolverXFeedbackRms is the square-root of the Resolver sine voltage squared plus the Resolver cosine voltage squared. This value is useful to determine if the resolver inputs are all properly connected.
Units/Bounds: Voltage, RMS, typically between 0 and 2.5V.

Variable name: **ResolverXSinRms**
Summary: Motor X Resolver measured voltage RMS.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. For Dragon1 systems, the ResolverXSinRms is raw resolver sine voltage; for Dragon2 systems, the ResolverXSinRms is the sine voltage squared.
Units/Bounds: Voltage, RMS, typically between 0 and 1V.

Variable name: **ResolverXCosRms**
Summary: Motor X Resolver measured voltage RMS.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. For Dragon1 systems, the ResolverXCosRms is raw resolver cosine voltage; for Dragon2 systems, the ResolverXCosRms is the cosine voltage squared.
Units/Bounds: Voltage, RMS, typically between 0 and 1V.

7.24 Sensorless

Variable name: **SensorlessX.Degrees**

Summary: Motor X Sensorless position in degrees.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read Only. Shows the motor position in degrees, normalized to 0 to 360º.
Units/Bounds: Degrees, the valid values are 0 to 360.

Variable name: **SensorlessX.Radians**
Summary: Motor X Sensorless position in Radians.
HiDS location: Shown on Resolver page in Advanced tab.
Description: Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds: Radians, the valid values are 0 to 2π.

Variable name: **SensorlessX.RPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds: RPM, unbounded.

Variable name: **SensorlessX.FilteredRPM**
Summary: Motor X velocity in RPM
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if Sensorless feedback is selected).
Units/Bounds: RPM, unbounded.

Variable name: **SensorlessX.RadiansPerSecond**
Summary: Motor X velocity in Radians per second
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds: Radians per second, unbounded.

Variable name: **AutoSetSensorlessParameters**
Summary: Auto-sets Motor X sensorless startup parameters based on the Motor X settings.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. If 1 (true), automatically sets the following parameters:

Based on many motor settings, these auto-set parameters are often a good start for a prosperly tuned sensorless configuration.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **MxSmo.StartupCurrent**
Summary: Motor X sensorless starting / open-loop current.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. Similar to starting a motor in manual feedback, this current is often 25% to 50% of the motor's maximum rated continuous current.

Units/Bounds: Amps, bounded by Mx.MaxCurrentCommand and Mx.MinCurrentCommand.

Variable name: **MxSmo.MinOpenLoopIq**
Summary: Motor X sensorless ending open-loop current.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. When the back-EMF voltage is large enough to run sensorless in closed-loop, this variable sets the typical IqCmd required to run at the MxSmo.ClosedLoopRPMThreshold RPM.
Units/Bounds: Amps, bounded by Mx.MaxCurrentCommand and Mx.MinCurrentCommand.

Variable name: **MxSmo.OpenLoopRPMThreshold**
Summary: Motor X sensorless maximum Open Loop RPM.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. The MxSmo.ClosedLoopRPMThreshold variable sets the actual closed-loop RPM value. This variable is typically set to ~80% of MxSmo.ClosedLoopRPMThreshold, and the "blended region" is used to linearly scale the IqCmd from MxSmo.StartupCurrent to MxSmo.MinOpenLoopIq.
Units/Bounds: RPM, bounded by MotorXOverspeed.

Variable name: **MxSmo.ClosedLoopRPMThreshold**
Summary: Motor X sensorless minimum closed Loop RPM.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. The MxSmo.ClosedLoopRPMThreshold variable sets the actual closed-loop RPM value. This RPM value must generate sufficient back-EMF voltage to allow the sensorless algorithm to properly estimate the motor's electrical angle.
Units/Bounds: RPM, bounded by MotorXOverspeed.

Variable name: **MxSmo.OpenLoopRPMPerSec**
Summary: Motor X sensorless open loop acceleration.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. This variable sets the velocity acceleration in the open-loop region, which depends on the motor's inertia.
Units/Bounds: RPM/second, unbounded.

Variable name: **MxSmo.RPMToSwitchToMaxAccel**
Summary: Motor X sensorless RPM to switch to the MxSmo.AccelRPMPerSec acceleration.
HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. Typically this value is set to the same as MxSmo.ClosedLoopRPMThreshold; however sometimes a higher speed is required before sufficient back-EMF exists to increase acceleration.
Units/Bounds: RPM, bounded by MotorXOverspeed.

Variable name: **MxSmo.AccelRPMPerSec**
Summary: Motor X sensorless closed loop acceleration.

HiDS location: Shown on Sensorless page in Advanced tab.
Description: Read / Write. This variable sets the velocity acceleration in the closed-loop region, which depends on the motor's inertia.
Units/Bounds: RPM/second, unbounded.

7.25 System

Variable name: **Various**
Summary: Internal ESI Controller debug variables.
HiDS location: Shown on System page in Advanced tab.
Description: Read Only. Typically only ESI-internal debug variables

7.26 Serial

Variable name: **SerialControlInterfaceEnable**
Summary: Enables or disables the serial command interface.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. If the Controller supports an external RS422 command interface, it may be necessary to disable this interface in order to command the control via the HiDS Run Panel.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **SerialFeedbackInterfaceEnable**
Summary: Enables or disables the serial feedback interface.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. If the Controller supports an external RS422 command interface, this variable may be useful to debug that interface.
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **SerialBaud**
Summary: Sets the baud rate of the serial feedback interface.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. If the Controller supports an external RS422 command interface, this variable sets the baud rate used by the Controller.
Units/Bounds: Integer; the supported values are 300, 1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K, 230.4K, 460.8K, 921.6K, 1Meg, and 1.2Meg baud.

Variable name: **SerialResponseRate_ms**
Summary: Sets the feedback message interval in milliseconds.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. If the Controller supports an external RS422 command interface, this variable configures how many milliseconds between packets.
Units/Bounds: Milliseconds, the valid values are 1 to 65535.

Variable name: **SerialChecksumErrorCount**
Summary: Indicates the count of received packets with CRC or checksum errors.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read Only. If the Controller supports an external RS422 command interface, this variable is incremented for each packet received with an invalid CRC or checksum (depending on the specific protocol).
Units/Bounds: Integer, 0 to positive unbounded.

Variable name: **SerialChecksumPassCount**
Summary: Indicates the count of received packets with no CRC or checksum errors.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read Only. If the Controller supports an external RS422 command interface, this variable is incremented for each packet received with an valid CRC or checksum (depending on the specific protocol).
Units/Bounds: Integer, 0 to positive unbounded.

Variable name: **SerialCharactersReceived**
Summary: Indicates the count of received bytes via the RS422 interface.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read Only. If the Controller supports an external RS422 command interface, this variable is incremented for each byte received on the RS422 interface.
Units/Bounds: Integer, 0 to positive unbounded.

Variable name: **SerialNumReportedErrors**
Summary: Indicates the count of errors reported by the RS422 transceiver.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read Only. If the Controller supports an external RS422 command interface, this variable is incremented for error reported by internal serial transceiver. The transceiver error flag indicates that one of the error flags in the receiver status register is set. This flag is a logical OR of the break detect, framing error, overrun, and parity error enable flags.
Units/Bounds: Integer, 0 to positive unbounded.

Variable name: **RS422CommandModeX**
Summary: Sets the RS422 command mode (current, velocity, or position) for Motor X.
HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. The ESI Motion RS422 protocol can be used for either Current, Velocity, or Position control. Refer to ESI Document 100121, RS422 Command Protocol for details.
Units/Bounds: Integer, 0 for Torque/Current commands, 1 for Velocity, and 2 for Position control.

Variable name: **RS422CommandCurrentScaleX, RS422CommandVelocityScaleX, RS422CommandPositionScaleX**
Summary: Sets the resolution of the 16-bit RS422 command mode, which is either in current, velocity, or position mode; see RS422CommandModeX.

HiDS location: Shown on Serial page in Advanced tab.
Description: Read / Write. The ESI Motion RS422 protocol can be used for either Current, Velocity, or Position control. The incoming 16-bit value is multiplied by this value to set either Mx.IqUserCommand, MxVL.RPMUserCommand, or MxPL.RadiansUserCommand. Refer to ESI Document 100121, RS422 Command Protocol for details.
Units/Bounds: Floating point; unbounded.

7.27 Serial Encoder

The Serial Encoder page shows the state and configuration variables related to the 2 BISS Serial Encoder interfaces. The Serial Encoder variables are shown as follows:

Variable name: **SerialEncoderX.Radians**
Summary: Motor Serial Encoder Motor X position in Radians.
HiDS location: Shown on SerialEncoder page in Advanced tab.
Description: Read Only. Shows the motor position in radians, normalized to 0 to 2π.
Units/Bounds: Radians, the valid values are 0 to 2π.

Variable name: **SerialEncoderX.Degrees**
Summary: Serial Encoder Motor X SerialEncoder position in degrees.
HiDS location: Shown on SerialEncoder page in Advanced tab.
Description: Read Only. Shows the motor position in degrees, normalized to 0 to 360^o.
Units/Bounds: Degrees, the valid values are 0 to 360.

Variable name: **SerialEncoderX.RPM**
Summary: Serial Encoder Motor X velocity in RPM
HiDS location: Shown on SerialEncoder page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in revolutions per minute.
Units/Bounds: RPM, unbounded.

Variable name: **SerialEncoderX.FilteredRPM**
Summary: Serial Encoder Motor X velocity in RPM
HiDS location: Shown on SerialEncoder page in Advanced tab.
Description: Read Only. Shows the filtered motor velocity in revolutions per minute; the filter is a ~4Hz low-pass filter, and this is the value shown on the Run Panel RPM gauge (if SerialEncoder feedback is selected).
Units/Bounds: RPM, unbounded.

Variable name: **SerialEncoderX.RadPer_us**
Summary: Serial Encoder Motor X velocity in Radians per microsecond
HiDS location: Shown on SerialEncoder page in Advanced tab.
Description: Read Only. Shows the unfiltered motor velocity in radians per microsecond.
Units/Bounds: Radians per microsecond, unbounded.

Variable name:	**SerialEncoderX.RadiansPerSecond**
Summary:	Serial Encoder Motor X velocity in Radians per second
HiDS location:	Shown on SerialEncoder page in Advanced tab.
Description:	Read Only. Shows the unfiltered motor velocity in radians per second.
Units/Bounds:	Radians per second, unbounded.

Variable name:	**SerialEncoderXData.PositionRaw**
Description:	Read only. This is the un-modified 32bit position value received from the Serial Encoder.

Variable name:	**SerialEncoderXData.PositionScaled**
Description:	Read only. This is the 32bit PositionRaw value multiplied by SerialEncoderConfig.ResolutionInRadians.

Variable name:	**SerialEncoderXData.Error**
Description:	Read only. This is the un-modified 1-bit Error value received from the Serial Encoder.

Variable name:	**SerialEncoderXData.Warning**
Description:	Read only. This is the un-modified 1-bit warning value received from the Serial Encoder.

Variable name:	**SerialEncoderXData.CRCReceived**
Description:	Read only. This is the un-modified 6-bit CRC value received from the Serial Encoder.

Variable name:	**SerialEncoderXData.CRCCalculated**
Description:	Read only. This is the 6-bit CRC value calculated from the received packet from the Serial Encoder.

Variable name:	**SerialEncoderXData.NumErrorPackets**
Description:	Read only. This variable is incremented every time SerialEncoderData.Error occurs.

Variable name:	**SerialEncoderXConfig.NumPositionBits**
Description:	Read / Write. This configures the number of position bits supplied by the BISS Serial Encoder. Note only 16, 18, 26, and 32-bit Serial Encoders are supported.

Variable name:	**SerialEncoderXConfig.ResolutionInRadians**
Description:	Read / Write. This configures the scaler to multiply the PositionRaw value to convert to actual Radians.

Variable name:	**SerialEncoderXConfig.ClockFrequencyMhz**
Description:	Read / Write. This configures the frequency of the clock to use to clock the data out of the Serial Encoder BISS interface. Only 2, 4, and 8Mhz are supported. To change this configuration, one must change the value, save it into non-volatile (Flash) memory, and power-cycle the Controller.

7.28 TestPoint

Variable name: **Various**
Summary: Internal ESI Controller debug variables.
HiDS location: Shown on TestPoint page in Advanced tab.
Description: Read Only. These are ESI-internal debug variables used to show the various states of the digital and analog test points.

7.29 Temperature

Often all of the relevant temperature values can be viewed within the HiDS Run Panel.

Variable name: **DSPTemp**
Summary: Shows the current temperature of the Digital Signal processor.
HiDS location: Shown on Temperature page in Advanced tab.
Description: Read Only. Shows the current DSP temperature.
Units/Bounds: Degrees Celsius.

Variable name: **MxMotorTemp**
Summary: Shows the current temperature of the Motor X thermistor.
HiDS location: Shown on Temperature page in Advanced tab.
Description: Read Only. Shows the current motor-temperature(s) if supported.
Units/Bounds: Degrees Celsius.

Variable name: **MxIGBTTemp**
Summary: Shows the current temperature of the Motor X IGBT/Mosfet.
HiDS location: Shown on Temperature page in Advanced tab.
Description: Read Only. Shows the current gate-driver-temperature(s) if supported.
Units/Bounds: Degrees Celsius.

Variable name: **MaMotorTempX0Coeff – MaMotorTempX3Coeff, MbMotorTempX0Coeff – MbMotorTempX3Coeff**
Summary: Sets the motor temperature coefficients
HiDS location: Shown on Temperature page in Advanced tab.
Description: Read / Write. The Temperature input is an active circuit that measures an NTC thermistor which is directly proportional to motor temperature. The temperature vs resistance polynomial can be configured through software and provides the user with up to 4 polynomial coefficients, X0-X3. The temperature equation is of the form:
Temperature = $(X3 * v^3) + (X2 * v^2) + (X1 * v) + X0$, where:
v = 3 * (1000 / (measured NTC thermistor resistance + 2000))
Units/Bounds: Unit-less, unbounded.

7.30 Utility

Variable name: **Mx.IcmdInputScale**
Description: Read / Write. Mx.IcmdInputScale sets the scale used to multiply the Mx.

IcmdAnalogInputinput to produce a current input to the torque loop based on the analog voltage input provided. When Mx. IcmdAnalogInputis unused, this value is set to zero. This value is summed with Mx.IqUserCommand and Mx.DesiredCurrent and (SinTest.output * SinTest.iq_amplitude) to produce Mx.IqCmd.
Units/Bounds: Amps per volt, unbounded.

Sintest is a flexible sine-wave / square-wave generator whose output can be bound to the inputs of the current, velocity, or position loop. Using an automated sine input is useful for basic system bring up as well as dynamic system response testing.

Variable name: **SinTest.output**
Description: Read Only. SinTest.output is the resulting sine output, at the frequency defined by SinTest.frequency, and SinTest.hz_per_second (if non-zero).
Units/Bounds: Sinusoidal, -1 to 1.

Variable name: **SinTest.angle**
Description: Read Only. SinTest.angle is the resulting sine output angle, as it rotates at the frequency defined by SinTest.frequency, and SinTest.hz_per_second (if non-zero).
Units/Bounds: Radians, 0 to 2π.

Variable name: **SinTest.frequency**
Description: Read / Write. SinTest.frequency sets the frequency output of the SinTest function.
Units/Bounds: Hertz, 0 to 40KHz, depending on controller architecture.

Variable name: **SinTest.hz_per_second**
Description: Read / Write. Should a swept-sine input be required (for frequency sweeps), SinTest. hz_per_second sets the hertz-per-second of the sweep. 0 disables the sweep (constant frequency).
Units/Bounds: Hertz per second, 0 to ~200, depending on controller architecture.

Variable name: **SinTest.seconds_per_decade**
Description: Read / Write. For large frequency sweeps, this variable sets the number of seconds per frequency decade.
Units/Bounds: Seconds per frequency-decade, unbounded.

Variable name: **SinTest.min_hz**
Description: Read / Write. For swept-sine operations, SinTest.min_Hz sets the frequency to roll-over to once SinTest.max_Hz is reached.
Units/Bounds: Hertz, 0 to 40KHz, depending on controller architecture.

Variable name: **SinTest.max_hz**
Description: Read / Write. For swept-sine operations, SinTest.max_Hz sets the maximum frequency to roll-over to SinTest.min_Hz.
Units/Bounds: Hertz, 0 to 40KHz, depending on controller architecture.

Variable name: **SinTest.update_time**

Description: Read Only. SinTest. update_time is the sine-test update rate at which the angle and output are calculated.
Units/Bounds: Seconds per update, typically 10-50ms, depending on controller architecture.

Variable name: **SinTest.OutputIsSquarewave**
Description: Read / Write. If true, the sine-test output is a square wave..
Units/Bounds: Boolean, the valid values are 0 or 1.

Variable name: **SinTest.iq_amplitude**
Description: Read / Write. SinTest.iq_amplitude sets the scale used to multiply the SinTest.output to produce the IQ current input to the torque loop. When the SinTest is unused, this value is set to zero. The (SinTest.output * SinTest.iq_amplitude) result is summed with Mx.IqUserCommand, Mx.DesiredCurrent, and (HighSpeedIcmdInput * Mx.IcmdInputScale) to produce Mx.IqCmd.
Units/Bounds: Amps, bounded by Mx.MinCurrentCommand and Mx.MaxCurrentCommand.

Variable name: **SinTest.id_amplitude**
Description: Read / Write. SinTest.id_amplitude sets the scale used to multiply the SinTest.output to produce the ID current input to the torque loop. When the SinTest is unused, this value is set to zero. The (SinTest.output * SinTest.id_amplitude) result is summed with Mx.IdUserCommand to produce Mx.IdCmd.
Units/Bounds: Amps, bounded by Mx.MinCurrentCommand and Mx.MaxCurrentCommand.

Variable name: **SinTest.VelocityCommandAmp**
Description: Read / Write. SinTest.VelocityCommandAmp sets the scale used to multiply the SinTest.output to produce the velocity input to the velocity loop. When the SinTest is unused, this value is set to zero. The (SinTest.output * SinTest.velocity_amp) result is summed with MxVL.RPMUserCommand, MxPL.DesiredRPM, and (IcmdInput * MxVL.VcmdInputScale) to produce MxVL.RPMCommand. This is useful to verify the system's closed-loop response.
Units/Bounds: RPM, unbounded.

Variable name: **SinTest.VelocityErrorAmp**
Description: Read / Write. SinTest.VelocityErrorAmp sets the scale used to multiply the SinTest.output to produce the velocity input summed with RPMError within the velocity loop. This is useful to verify the system's open-loop response.
Units/Bounds: RPM, unbounded.

Variable name: **SinTest.position_amp**
Description: Read / Write. SinTest.position_amp sets the scale used to multiply the SinTest.output to produce the position input to the position loop. When the SinTest is unused, this value is set to zero. The (SinTest.output * SinTest.position_amp) result is summed with

	MxPL.RadiansUserCommand, (IcmdInput * MxPL.PcmdInputScale) to produce MxPL.RadiansCommand.
Units/Bounds:	Radians, unbounded.

Variable name:	**SinTest.EnablePositionFilter**
Description:	Read / Write. SinTest.EnablePositionFilter enables a 1Hz filter on the SinTest.position_amp value. In position-loop based systems, a step-change in the position can be undesired. Enabling this filter softens changes in the SinTest.position_amp variable.
Units/Bounds:	Boolean, the valid values are 0 or 1.

7.31 Velocity Loop

Variable name:	**MotorXVelocityEnable**
Description:	Read / Write. This variable would normally be changed via the [Loop Gains] tab Control Mode dropdown list. However if this variable is included in an imported text file, the values to use are: 0=Torque/Current mode and 1 = Velocity Mode.
Units/Bounds:	Boolean, 0=Torque/Current mode and 1 = Velocity Mode.

Variable name:	**MxVL.MinRPMCommand**
Description:	Read / Write. MxPL.MinRPMCommand limits the lower value of the input to the velocity loop.
Units/Bounds:	RPM, unbounded.

Variable name:	**MxVL.MaxRPMCommand**
Description:	Read / Write. MxVL.MaxRPMCommand limits the upper value of the input to the velocity loop.
Units/Bounds:	RPM, unbounded.

Variable name:	**MxVL.RPMUserCommand**
Description:	Read / Write. MxVL.RPMUserCommand sets the desired motor velocity in RPM. This value is summed with (Mx. IcmdAnalogInput* MxVL.VcmdInputScale) and MxPL.DesiredRPM (the output from the position loop) to produce MxVL.RPMCommand.
Units/Bounds:	RPM, unbounded.

Variable name:	**MxVL.RPMCommand**
Description:	Read Only. MxVL.RPMCommand is the final velocity input into the velocity loop, and is the sum of MxVL.RPMUserCommand, MxPL.DesiredRPM (the output from the position loop), and (Mx. IcmdAnalogInput* MxPL.PcmdInputScale).
Units/Bounds:	RPM, unbounded.

Variable name:	**MxVL.AccelLimitedRPMCommand**
Description:	Read Only. For a step-response input to MxVL.RPMCommand, the MxVL.AccelLimitedRPMCommand variable is the resulting velocity action that is limited by the velocity acceleration value setting variable MxPL.AccelRPMPerSec.

Units/Bounds: RPM, unbounded.

Variable name: **MxVL.AccelRPMPerSec**
Description: Read / Write. For a step-response input to MxVL.RPMCommand, the MxVL.AccelRPMPerSec velocity acceleration variable limits the resulting velocity command, which is indicated by MxVL.AccelLimitedRPMCommand.
Units/Bounds: RPM per second, positive only.

Variable name: **MxVL.VcmdInputScale**
Description: Read / Write. MxVL.VcmdInputScale sets the scale used to multiply the Mx. IcmdAnalogInputinput to produce a velocity input to the velocity loop based on the analog voltage input provided. When Mx. IcmdAnalogInputis unused, this value is set to zero. This value is summed with MxVL.RPMUserCommand and MxPL.DesiredRPM to produce MxVL.RPMCommand.
Units/Bounds: RPM per volt, unbounded.

Variable name: **MxVL.RPMError**
Description: Read Only. MxVL.RPMError indicates the velocity error. MxVL.RPMError = MxVL.AccelLimitedRPMCommand - <FeedbackType>.RPM.
Units/Bounds: RPM, unbounded.

Variable name: **MxVL.FrictionFeedForward**
Description: Read /Write. For motor-systems that may have varying friction or inertia that is dependent on motor-speed, MxVL. FrictionFeedForward is a friction-based feed-forward to the velocity-loop. This feed-forward produces a current, MxVL.FrictionFeedForwardCurrent, that is added into Mx.DesiredCurrent. MxVL.FrictionFeedForwardCurrent = MxVL.AccelLimitedRPMCommand * MxVL.FrictionFeedForward.
Units/Bounds: Amps per RPM, unbounded.

Variable name: **MxVL.StepFeedForward**
Description: Read /Write. For motor-systems that may have an initial inertia or startup friction to overcome, MxVL.StepFeedForward is an inertia-based feed-forward to the velocity-loop. This feed-forward produces a current, {MxVL.StepFeedForward * signof(MxVL.AccelLimitedRPMCommand)} that is added into Mx.DesiredCurrent.
Units/Bounds: Amps, unbounded.

7.32 Hardware Test

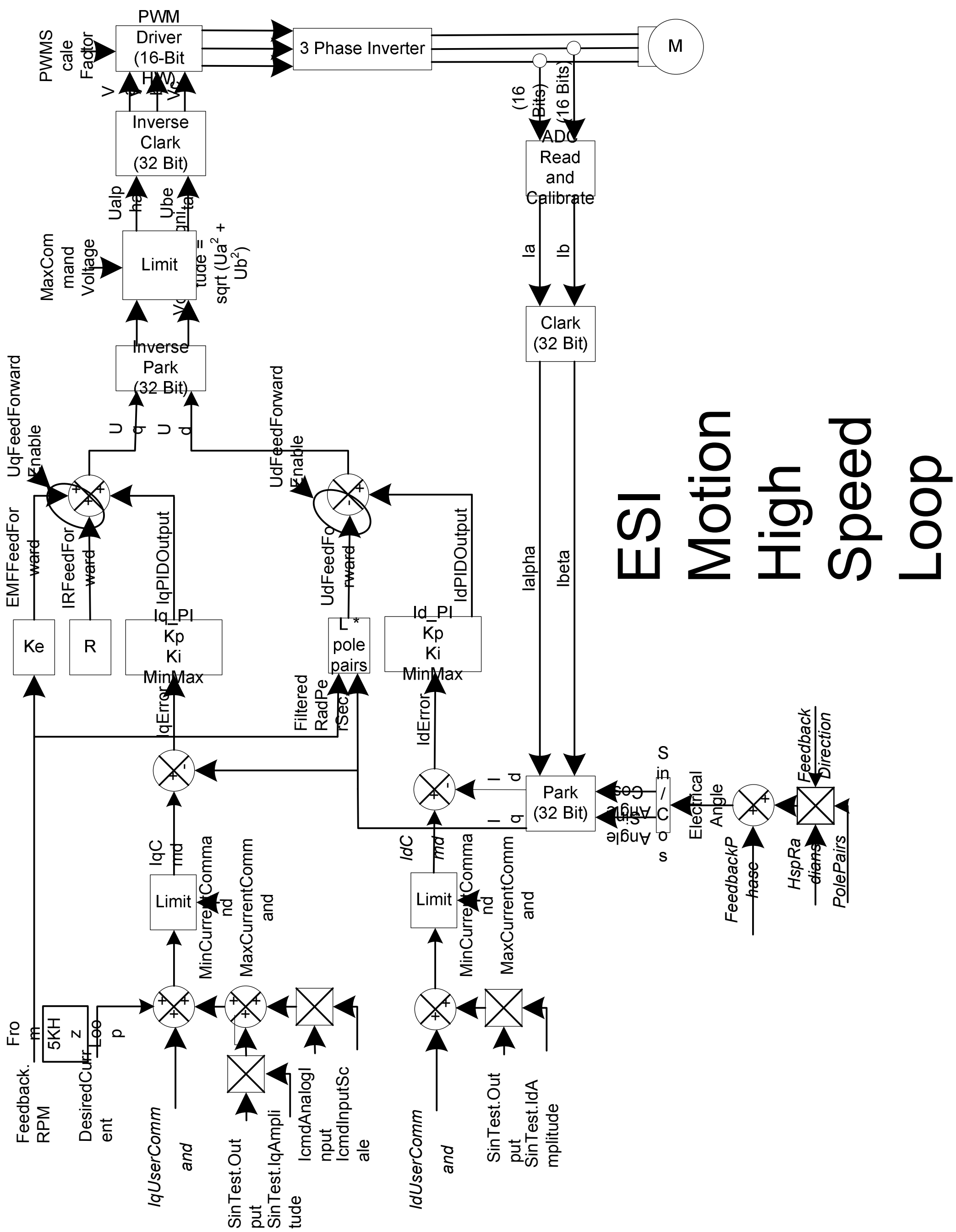
Variable name: **Various**
Summary: Internal ESI Controller debug variables.
HiDS location: Shown on Hardware Test page in Advanced tab.
Description: Read Only. These are ESI-internal debug variables used to test various internal sub-systems of the Controller.

7.33 User Defined

Variable name: **Various**
Summary: Displays all variables added to the User Defined page.
HiDS location: Shown on Hardware Test page in Advanced tab.
Description: Read Only. This page displays all variables added to the User Defined page. The User Defined page is described above.

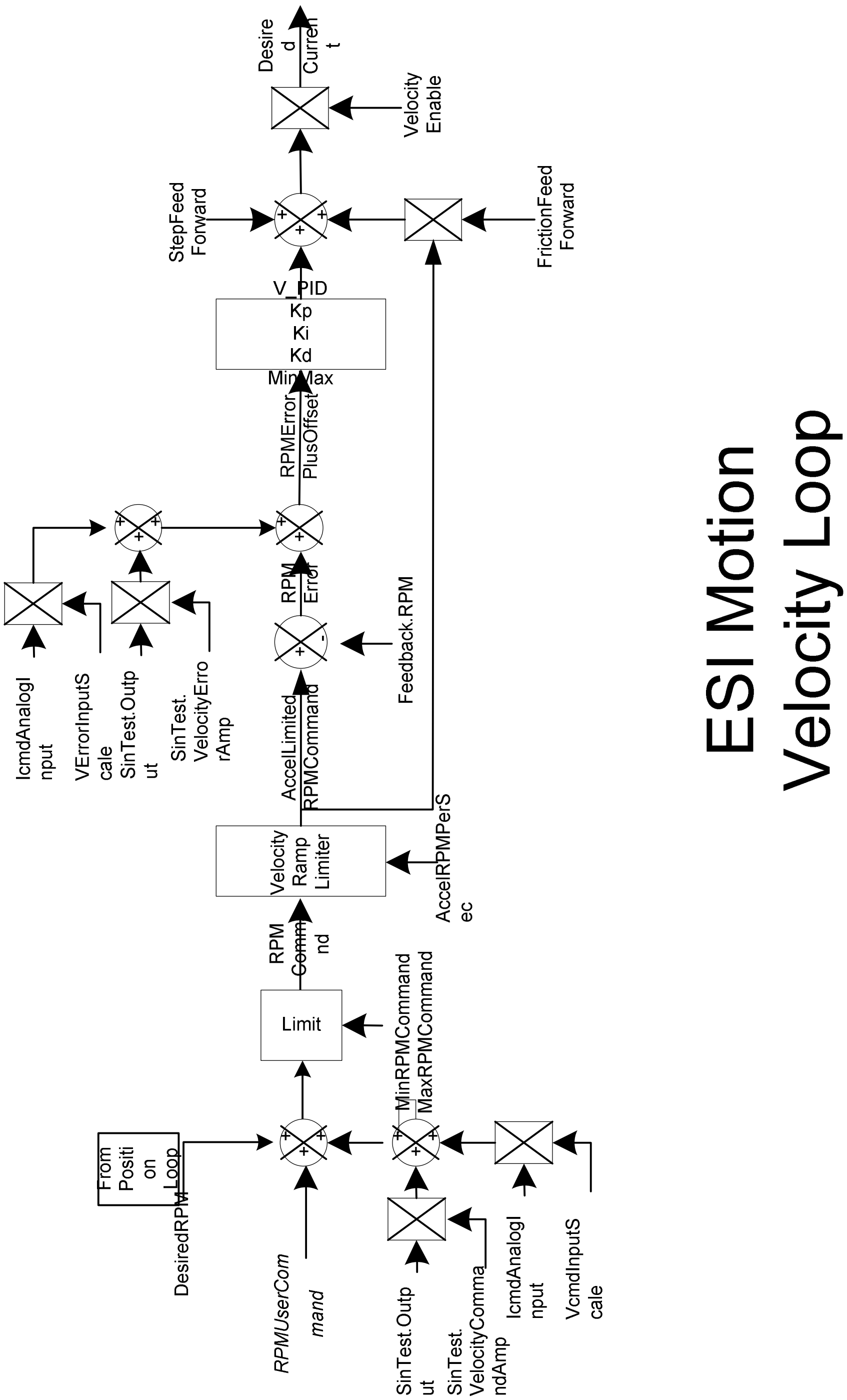
8 APPENDIX B: THE ESI MOTION CURRENT LOOP DIAGRAM

Note some of the variable names are abbreviated in the large drawing in order to fit on one page.



9 APPENDIX C: THE ESI MOTION VELOCITY LOOP DIAGRAM

Note some of the variable names are abbreviated in the large drawing in order to fit on one page.



10 APPENDIX C: THE ESI MOTION POSITION LOOP DIAGRAM

Note some of the variable names are abbreviated in the large drawing in order to fit on one page.