AXLC LOCAL EWRITE
For AX022320

USER MANUAL

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1. OVERVIEW OF CONTROLLER

The Axiomatic Local Controller (AXLC) Local EWRITE is a software configuration tool that runs on a PC connected to the 1-wire communication harness, AX070127. Upon communication between the controller and the GUI, the user has easy configurability access to all the parameters. With AXLC Local EWRITE, viewing, changing parameters and loading configuration files is easy and intuitive – allowing the user to program the controller to a wide variety of applications.

2. Using the AXLC Local EWRITE Tool

In some input modes, particularly the 0-10V type, the output could be engaged when the communication adaptor is connected since the voltage on the input would read as approximately 5.7V to 6.3V depending on the system. If this value is within the valid input range, the controller will not necessarily know that the communication adaptor has been connected. For this reason, it is recommended that the outputs be disconnected in critical systems before connecting the communication adaptor.

When the controller is configured as a 0-20mA or 4-20mA input type, the controller will begin decrementing a 10s counter at power up. If communication has been established with the AXLC Local EWRITE within 10 seconds, the controller will not measure any input current while the unit is ON and will engage only in communication. Similarly, if no communication has been established, the controller will not receive or transmit any data for as long as the unit is ON and will continuously be measuring current inputs. Therefore, a power cycle needs to be performed in order to switch input functionality.

2.1. Main Window

When first opening the AXLC EWRITE tool, you will see the startup screen with the following main options:

   a. *CONNECT*
   b. *CHANGE TYPE* (Not accessible at startup)
   c. *VIRTUAL UNIT*
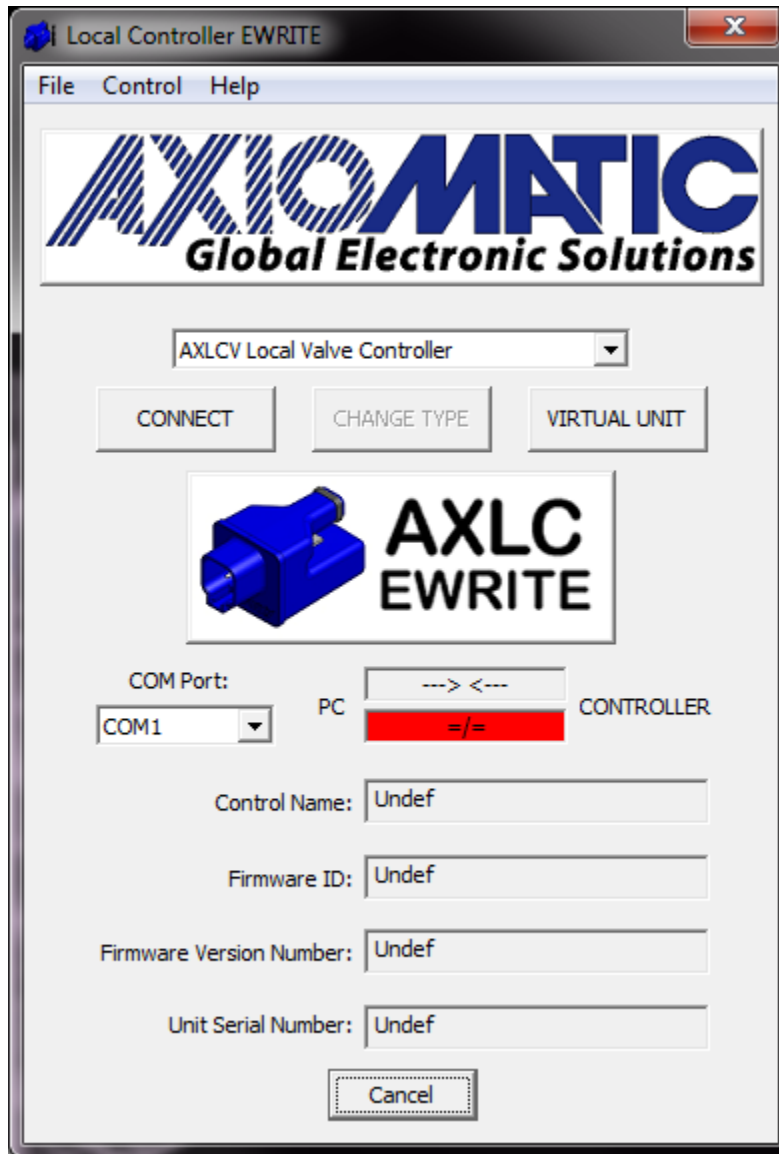
Before connecting to the unit, make sure that the appropriate COM port has been selected for your computer. By default, the program will use COM1, but you can select a different port if necessary.

Hit the "CONNECT" button and the program will read the controller's active **model type** from the unit and display it on the screen. Additional information will also be read from the unit to identify helpful details such as the version of the firmware running on the unit, and the unit's serial number. When the information displayed on the screen has been synchronized with the unit, the indicator between the PC and CONTROLLER will turn green. Hit the CONTINUE button to see the active configuration of the model type selected.
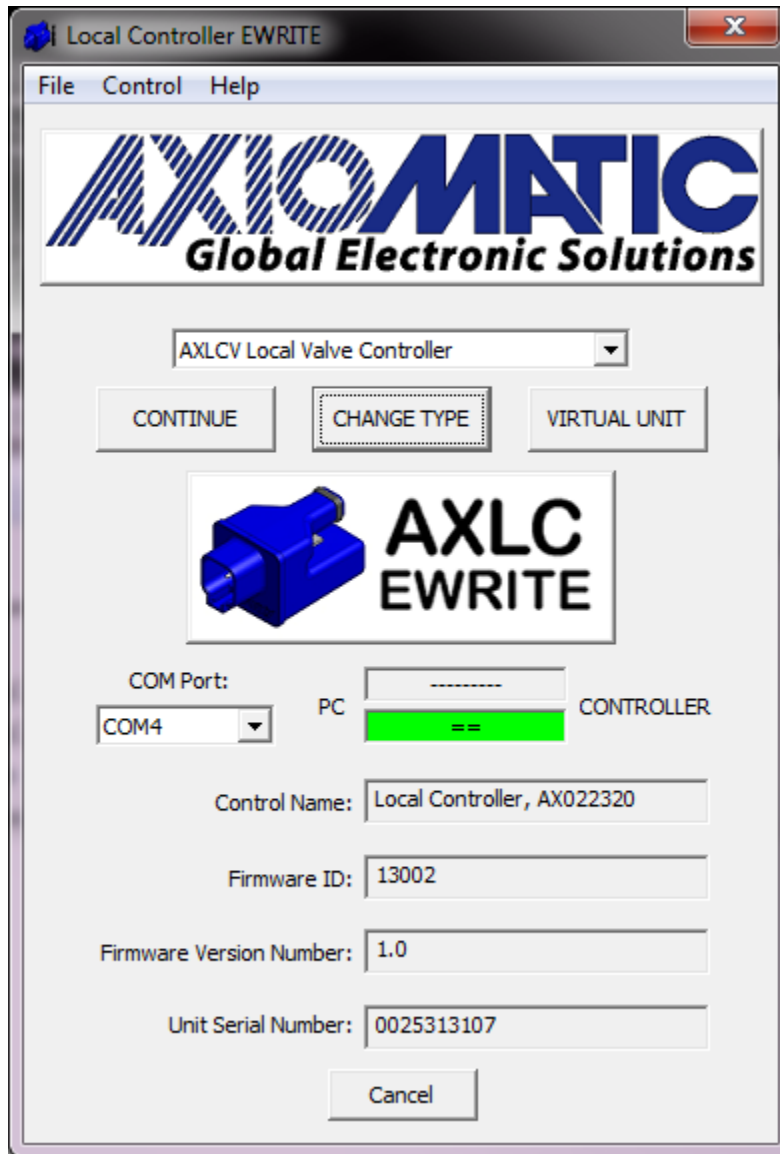
Alternately, once the EWRITE tool has successfully connected to the unit, the *CHANGE TYPE* button becomes enabled. If a new model type is selected from the drop list, the indicator will turn red showing that the type selected does not match the unit. In this case the *CONTINUE* button becomes disabled until the appropriate model type has been reselected, or the *CHANGE TYPE* operation has been executed. When the model type is changed, the AXLC will automatically update itself to run the defaults for the new model selected. If the *CONTINUE* button is hit right away, there may be a delay before the EWRITE program is able to communicate with the unit as it is processing the updates.

The last button, *VIRTUAL UNIT* allows you to go to select any model type, and see the corresponding configuration screen without having an actual unit connected. This is a helpful feature when you want to create, review or edit a configuration file (.vdr, .fdr or .tdr), or to demonstrate the features of the programming tool. When a *VIRTUAL UNIT* has been selected, the Read and Write buttons are disabled for all types of controllers.

2.2.   Configuration Files

For all controller types, the user has the option to save a configuration file at any point during a setup. The saved file could then be loaded onto the next controller of the same type (i.e. AXLCV) without having to individually change each variable.

Alternatively, the user can use the *VIRTUAL UNIT* to pre-configure a particular response without needing the unit connected, and then later load the created configuration onto a real unit to test the behaviour of the system.

Each type of controller will only load configuration files of the appropriate extension.

AXLCV Local Valve Controllers will generate and load **.vdr** files

AXLCF Local Fan Controllers will generate and load **.fdr** files

AXLCT Local Transmission Controllers will generate and load **.tdr** files

AXLCTI Local Inverse Transmission Controllers will generate and load **.itdr** files

When the **Load Configuration** or **Save Configuration** buttons are selected, the program will allow the user to browse for the directory to load/save the desired configuration.
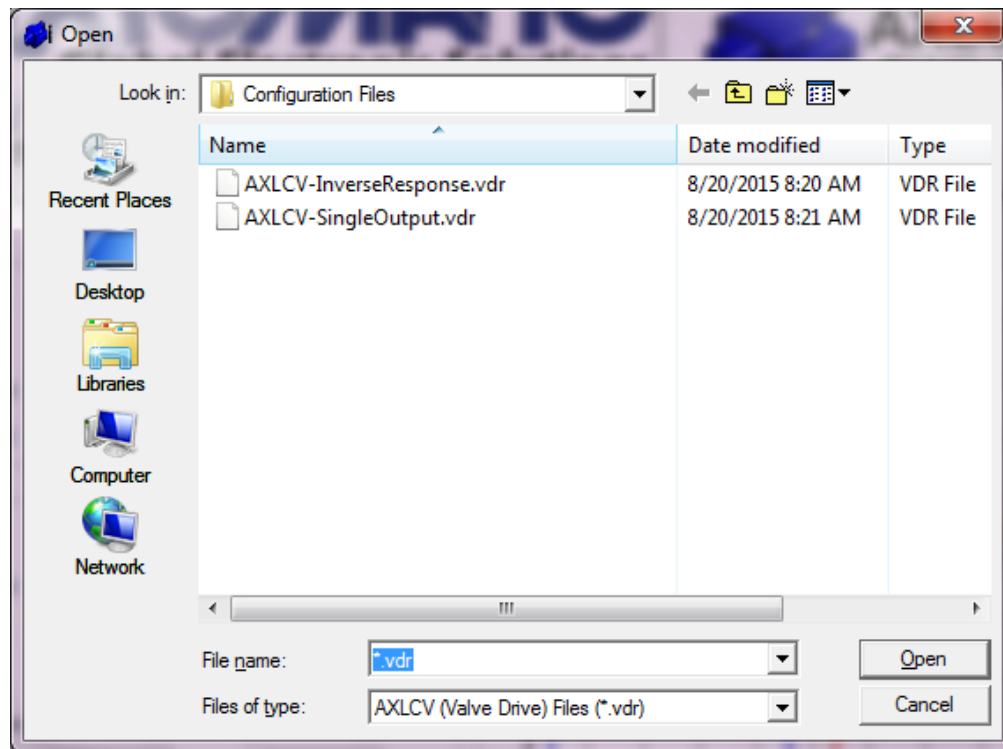
3. AXLCV Local Valve Controller Help

3.1. PINOUT

1	Sol B -
2	Signal -
3	Signal +
4	Power +
5	Power -
6	Sol B +

1	Sol A +
2	Sol A -
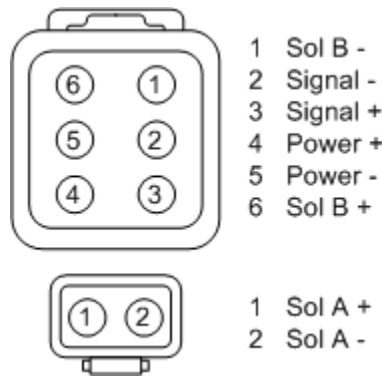
3.2. DEFAULTS

The screen capture below shows the **default** configuration of an AXLCV controller as received from the factory
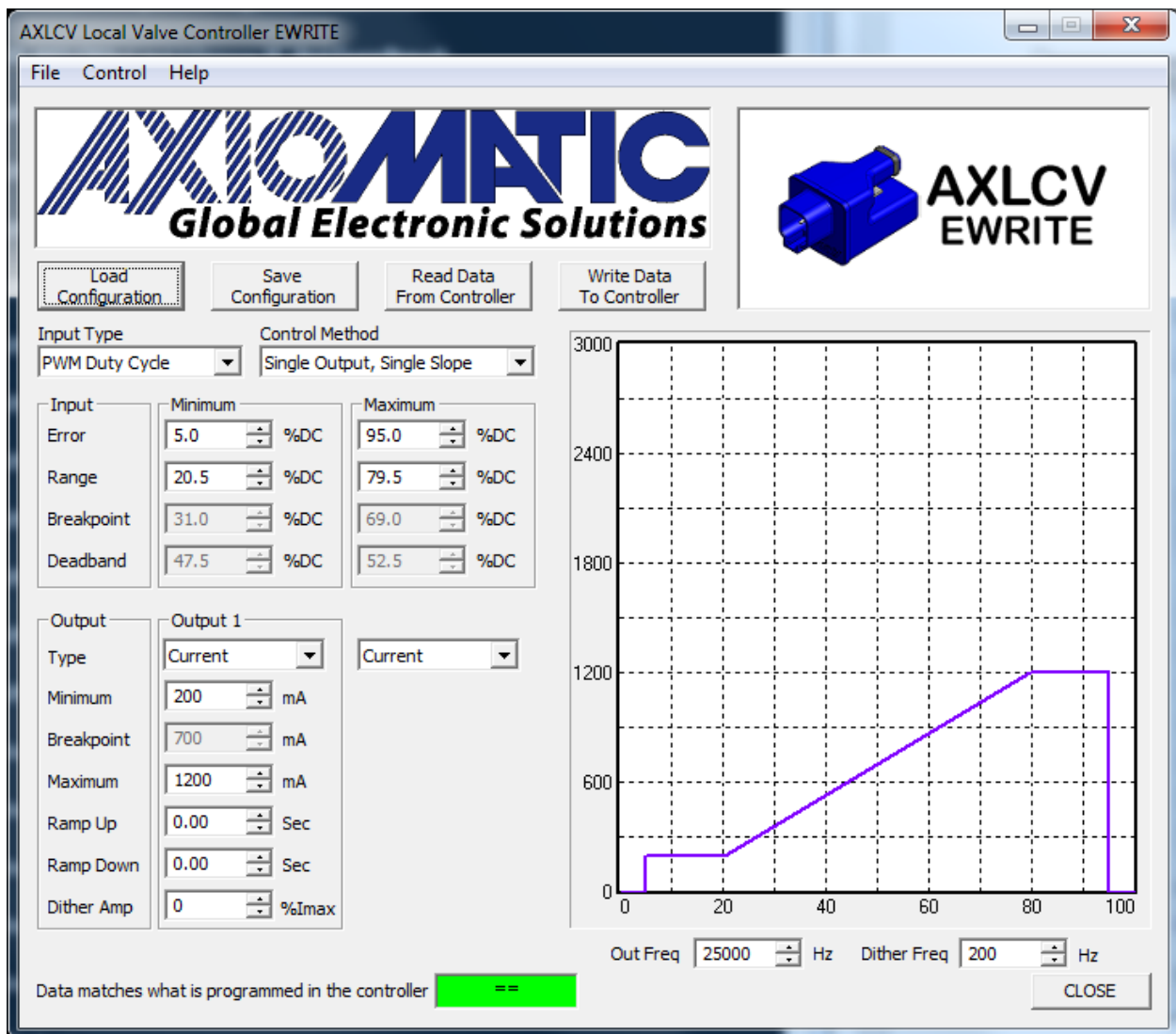
This image shows the **default** configuration of a virtual AXLCV

An important distinction to note between the two examples shown above is that on the first one, the bottom right hand corner shows the message "Data matches what is programmed in controller" with the synchronization box highlighted in green. However, on the second example, it shows that the data is not synchronized by the box showing red.

Any time after either the "Read Data From Controller" button or the "Write Data To Controller" button is selected, the program will communicate with the unit to read/write the variable configuration from/to the unit. As the program is communicating, the message under the graph will display the progress of the operation, as shown in the example below.

Once the program has successfully read/written the configuration, it knows that it has synchronized with the unit, and that it is correctly showing what the unit is doing. As soon as any variable has changed, it will update the message to remind the user that what they are seeing on the EWRITE tool does not match what is actually happening on the unit. Before testing the unit, a user should always make sure that the data shown on the tool matches what is in the unit by verifying the synchronization box is green.

Please note, with a *VIRTUAL UNIT* connection (selected from the main screen), the read/write buttons do not work, as the program assumes that no unit is connected.

3.3. INPUT TYPE

The controller supports a wide variety of *Input Type* options, as listed below. When changing the *Input Type* , all variables associated with the input are automatically updated for defaults that make sense for the selected type. The table below outlines the defaults for each type

Type	Unit	"B" Error Min	"B" Limit (Minimum)	"B" Breakpoint	"B" Deadband	"A" Deadband	"A" Breakpoint	"A" Limit (Maximum)	"A" Error Max **	Hysteresis (fixed by type)
PWM Duty Cycle	[%]	5.0	20.5	27.0	47.5	52.5	73.0	79.5	95.0	1.0
0-5 Volt	[V]	0.20	0.50	1.00	2.30	2.70	4.00	4.50	4.80	0.10
0-10 Volt	[V]	0.20	0.50	2.00	4.80	5.20	8.00	9.50	9.80	0.10
0-20 Milliamp	[mA]	1.5*	2.0	5.0	9.0	11.0	15.0	18.0	21.0	0.25
4-20 Milliamp	[mA]	1.5*	4.0	7.0	11.0	13.0	17.0	20.0	21.0	0.25
Resistive 0-5kOhm	[kOhm]	0.20*	0.50	1.00	2.30	2.70	4.00	4.50	4.80	0.10

*Error Min: Setting the *Error Min* input to zero will disable the error detection on the low end of the range. However, for current and resistive input types, the minimum error range is restricted to the minimums shown in the table above. The reason for this is that since communication with this configuration program is done through the same pin as the input, the unit needs to recognize when the communication adaptor (RS-232 to 1-wire) has been connected in order to turn off the current sense resistor (current types) or the current source (resistive types) to enable communication to be established. If error detection was disabled, the unit would be unable to ever re-connect to the computer.

**Error Max: For each type, the *Error Max* can be set higher than the range of the input (except for PWM) so that error detection at the upper end of the input range is disabled within the nominal input range. However, in all cases a short to +Vcc on the input would still cause the input to saturate, resulting in an error being flagged and the output shutting off. The only exception for this is the PWM type, where setting the Error Max to

100% would disable the error detection fully, and the output would stay at the corresponding output level in the case of a short to +Vcc. For 0-5V, the error range is up to 5.5V, 0-10V up to 11.0V, current types up to 21mA, and resistive types up to 5.5kOhm.

3.4.   OUTPUT TYPE & OUTPUT FREQUENCY

The controller supports a wide variety of *Output Type* options, as listed below. When changing the *Output Type*, all variables associated with the output are automatically updated for defaults that make sense for the selected type. The table below outlines the defaults for each type

Type	Unit	Minimum Range	Breakpoint	Default Maximum Range	Absolute Maximum Range	Default Output Frequency
Not Used	-	0.0	0.0	0.0	0.0	25000[Hz]*
Proportional Current	[mA]	200	700	1200	3000	25000[Hz]*
Proportional Voltage	[V]	0.0	10.0	20.0	30.0	25000[Hz]*
Proportional PWM Duty Cycle	[%DC]	5.0	45.0	95.0	100.0	25000[Hz]*

Out Frequency parameter can be set between 1Hz…25000Hz. Please note that the outputs are factory-calibrated at 25000Hz. Operating at different output frequency in *Proportional Current* mode may affect the accuracy. Axiomatic recommends operating at 25000Hz if in *Proportional Current* mode.

The output types can be selected in all available control methods (see Section 3.5).

3.5.   CONTROL METHOD
As can be seen from the two examples above, the AXLCV can be configured for a variety of responses. In fact, the following four *Control Method* options are supported:

Single Output, Single Slope
Single Output, Dual Slopes
Dual Output, Single Slopes
Dual Output, Dual Slopes

3.5.1.   Single Output, Single Slope
In this case, only Output A is ever used (the two pin output that plugs into the coil.) The output will respond linearly between the minimum and maximum input values. When the input is below the range, but above the minimum error threshold, the output will remain at the minimum current. When the output is above the range, but below the maximum error threshold, it will remain at the maximum current.

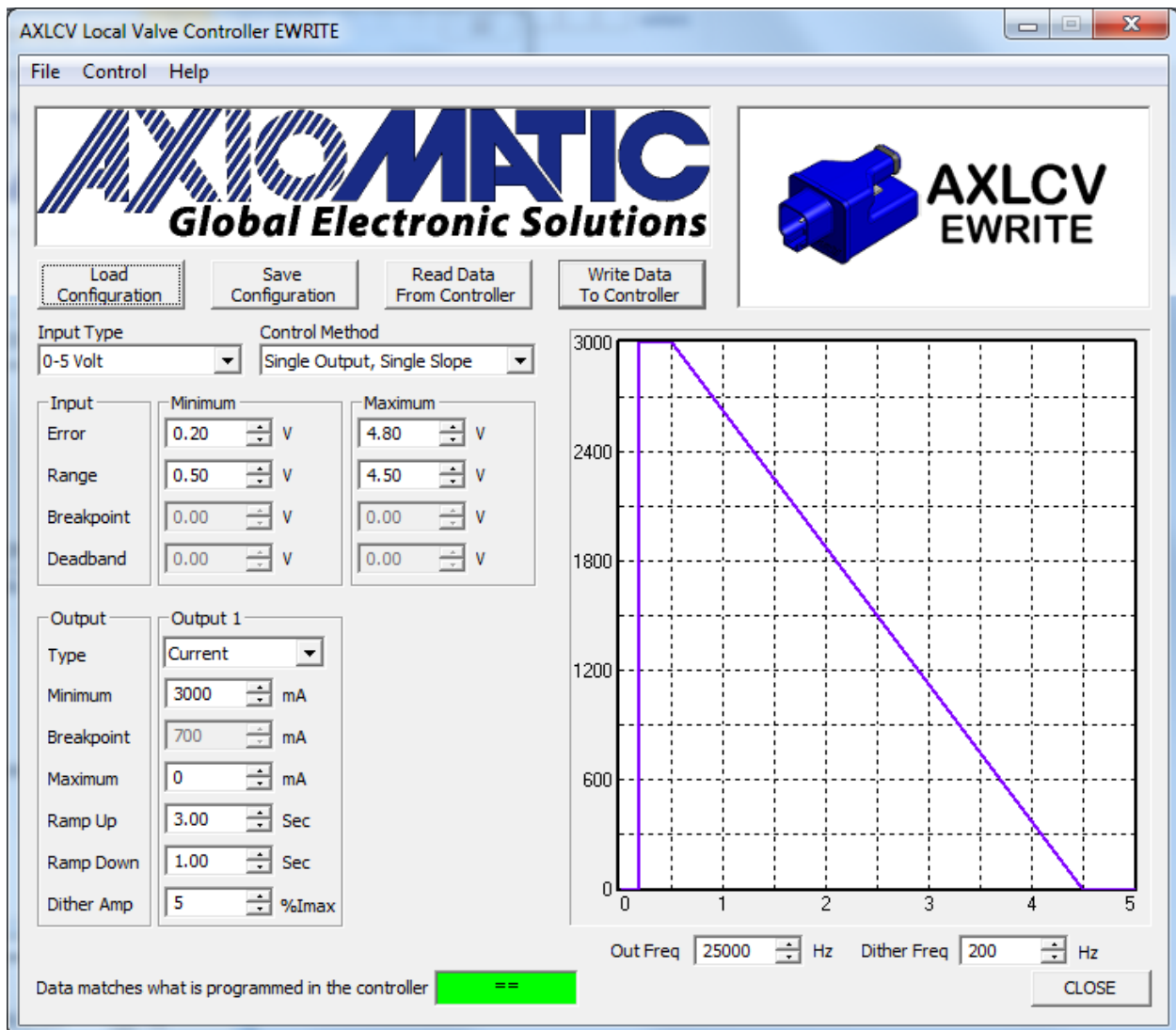In all cases, the following **input** constraint applies: *Error Min <= Minimum <= Maximum <= Error Max*

However, for the **output**, the current *Minimum* could be set greater than the *Maximum* resulting in an inverse output profile (i.e. as the input increases, the output decreases.) Here, the *Minimum* value corresponds to the value out the output at or below the *Minimum* input, and *Maximum* is at or above the *Maximum* input. See below for an example of an inverse output response.

Also, the example below shows non-zero *Ramp Up* and *Ramp Down* values. Ramp times are always relative from zero to the maximum current (if *Minimum > Maximum*, then the value in this box is considered the maximum output)

In the example below, it would take three seconds to ramp from zero to 3000 mA (3A), or a ramp rate of 1mA/ms, but on the way down, it would only take 1 second, or a ramp rate of 3mA/ms. Ramps should be used in applications where you want to 'soften' the response of the output current to a step-change at the input.

Lastly, in the example below, a non-zero dither value has been selected for the output. This enables dithering on the output, meaning that at a low frequency, the output will have some percentage of the maximum current (same note applies as with the ramps), added or subtracted to the target output value. In the example below, the *Dither Freq* is set to 200Hz, meaning that every 2.5ms half of the *Dither Amp* which was set to 5% of 3000mA, or ~75mA, will be either added to or subtracted from the target output current, i.e. 1000mA will oscillate between 925 to 1075mA.

The exact amplitude and frequency of the dither will depend partly on the properties of the coil itself, so the numbers will not necessarily be exact. The intent of having a low-frequency dither superimposed on top of the high frequency drive signal used to regulate the current through the load is to enable the valve to respond to minute changes in the current. It is meant to overcome the effects of static friction in the valve, so it should be optimized for the load to get the best results in system. A large enough amplitude should be selected to enable smooth responses, but not so large that it de-stabilizes the output accuracy.

AXLCV Local Valve Controller EWRITE

File   Control   Help

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AXLCV EWRITE

| Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller |

Input Type
0-5 Volt

Control Method
Single Output, Single Slope

Input

	Minimum	Maximum
Error	0.20 V	4.80 V
Range	0.50 V	4.50 V
Breakpoint	0.00 V	0.00 V
Deadband	0.00 V	0.00 V

Output — Output 1

Type	Current	
Minimum	3000	mA
Breakpoint	700	mA
Maximum	0	mA
Ramp Up	3.00	Sec
Ramp Down	1.00	Sec
Dither Amp	5	%Imax

Out Freq 25000 Hz   Dither Freq 200 Hz

Data matches what is programmed in the controller   ==

CLOSE

For all the variables shown, they can be changed by either the up/down arrows beside the box, or by entering a new value in the edit box. If the value that is entered is outside the valid range, the program will highlight the value in red, and prompt the user to reset the default value instead by selecting OK. If the Cancel option is selected, the edit box will go back to the value before the attempt to change it.
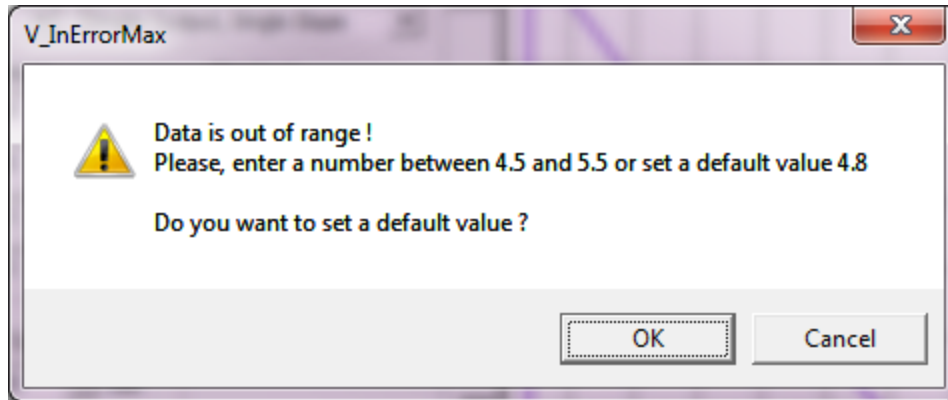
For example, in the image shown above, if the input *Maximum* were set to 5V, it would be automatically limited to 4.8V, since the Maximum cannot be larger than *Error Max*. To set the *Maximum* to 5V, the *Error Max* value would first have to be adjusted to >= 5V. Once that is done, the *Maximum* could be changed to 5V as desired.

Output current variables *Minimum*, *Breakpoint* (if applicable) and *Maximum* can be set between 0 to 3000mA.

Ramp Up (from zero to highest current on the curve) and *Ramp Down* (from highest current on the curve to zero) can be set between 0 to 60 seconds. Please note, setting it to 0sec disables ramping, and the output will respond immediately to a step change at the input.

Dither Amp (amplitude) as a percentage of the highest current on the curve can be set between 0 to 50%. Please note, setting it to 0% disables the dither.

Dither Freq (frequency) can be set between 50Hz to 400Hz

3.5.2. Single Output, Dual Slopes
This functionality is identical to the *Single Output, Single Slope* logic described above, except that the output can respond with two different slopes to changes at the input. The dual slope algorithms are described in more detail below in the *Dual Output, Dual Slopes* section.

Here, the following **input** constraint applies: *Error Min <= Minimum <= Breakpoint <= Maximum <= Error Max*

3.5.3. Dual Output, Single Slopes
This functionality is identical to the *Dual Output, Dual Slopes* section described below, except that each output will respond with a single slope (independent from one another) to changes in the input.

Here, the following **input** constraint applies: *Error Min <= "B" Limit (Minimum) <= "B" Deadband <= "A" Deadband <= "A" Limit (Maximum) <=Error Max*

3.5.4.   Dual Output, Dual Slopes

In this case, both outputs will react to changes at the input in a typical "deadband" profile. The response of Output A (the two pin output that plugs into the coil) versus that of Output B (the second output available on the 6 pin connector) do not have to match, as shown in the example below. While the profile shown in this example is not likely to be used in a real application, it does demonstrate a variety of features available with this *Control Method*.
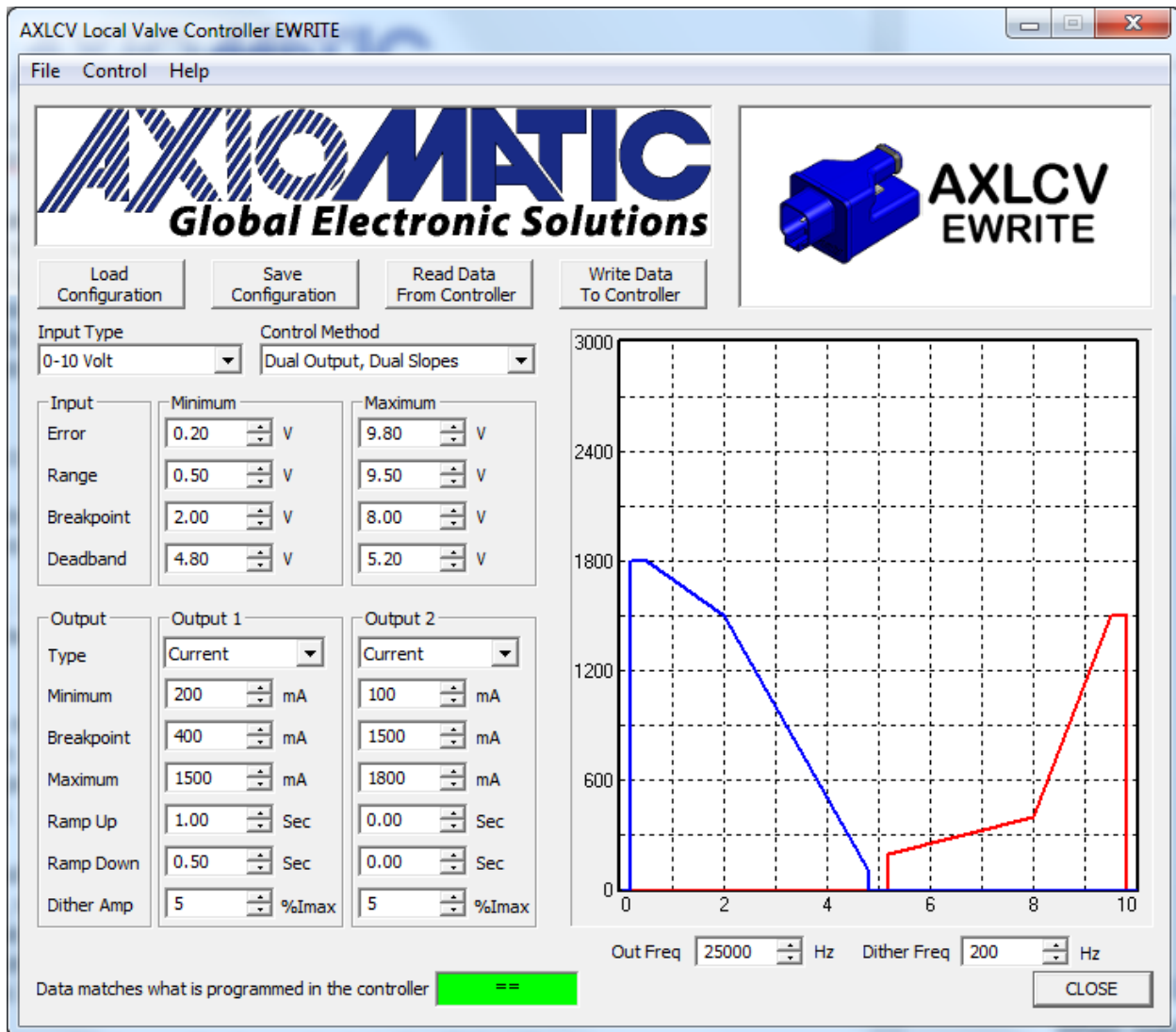
Here, the following **input** constraint applies:

Error Min <= "B" Limit (Minimum) <= "B" Breakpoint <= "B" Deadband <= "A" Deadband <= "A" Breakpoint <= "A" Limit (Maximum) <=Error Max

As with the *Single Output, Single Slope* method, this restriction needs to be taken into account when adjusting the input variables so that they are changed in the appropriate order.

Also, as before, there are no constraints on the output current variables *Minimum*, *Breakpoint*, and *Maximum.* They can be independently set anywhere between 0 to 3000mA, and it is the responsibility of the user to create an output profile that makes sense for their application.

Note, however, that it is automatically assumed by the program that Output "B" will have an inverse profile. That is, while the input decreased away from the deadband, the output current will increase. For both outputs, the *Maximum* current automatically corresponds to the point on the profile at input *"X" Limit*, while the Minimum current is at the *"X" Deadband.* (where X = A or B)

 The only variable that is shared between the two outputs is the *Dither Freq*. However, *Dither Amp* can be independently adjusted for both outputs.

AXLCV Local Valve Controller EWRITE

File   Control   Help

Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller

Input Type
0-10 Volt

Control Method
Dual Output, Dual Slopes

Input

	Minimum		Maximum	
Error	0.20	V	9.80	V
Range	0.50	V	9.50	V
Breakpoint	2.00	V	8.00	V
Deadband	4.80	V	5.20	V

Output

	Output 1		Output 2	
Type	Current		Current	
Minimum	200	mA	100	mA
Breakpoint	400	mA	1500	mA
Maximum	1500	mA	1800	mA
Ramp Up	1.00	Sec	0.00	Sec
Ramp Down	0.50	Sec	0.00	Sec
Dither Amp	5	%Imax	5	%Imax

Out Freq 25000 Hz   Dither Freq 200 Hz

Data matches what is programmed in the controller   ==

CLOSE

When reading the input to calculate what part of the output profile it is in, the unit has built-in hysteresis around the deadband and error points to prevent the output from oscillating on and off as the input rests at or near the threshold point. Hysteresis is fixed based on the input type (see table in *Input Type* section), and cannot be adjusted by the user.

3.5.5.   Dual Independent Outputs
This control method allows for both outputs to act independently throughout the entire range of the input. As such, the *Deadband* ranges are ignored and both outputs can operate simultaneously according to the command signal.

The outputs can be configured to respond linearly (single slope) throughout the input range or can be configured to have a breakpoint (double slope).

The *Breakpoint* parameter in the Input section is always enabled and can be used to enable/disable a double-slope response of the output. *Minimum Breakpoint* in the Input

section corresponds to *Output 1 Breakpoint* while *Maximum Breakpoint* in the Input section corresponds to *Output 2 Breakpoint*. Both, *Minimum Breakpoint* and *Maximum Breakpoint,* parameters in the Input section can be configured from *Minimum Range* to *Maximum Range*.

In order to have a single slope response on Output 1, *Minimum Breakpoint* must be configured to be equal to *Minimum Range* or *Maximum Range* of the Input section. Similarly, in order to have a single slope response on Output 2, *Minimum Breakpoint* must be configured to be equal to *Minimum Range* or *Maximum Range* of the Input section

The following shows the constraint of the parameters in the Input section:

Error Min <= Minimum Range <= Maximum Range <=Error Max

Minimum Range <= Minimum Breakpoint <= Maximum Range

Minimum Range <= Maximum Breakpoint <= Maximum Range

The *Out Frequency* can be set anywhere from As with the *Single Output, Single Slope* method, this restriction needs to be taken into account when adjusting the input variables so that they are changed in the appropriate order.
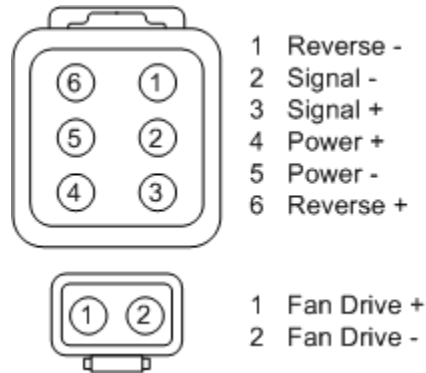
In the Output section, there are no constraints on the output current variables *Minimum*, *Breakpoint*, and *Maximum.* They can be independently set anywhere between 0 to 3000mA, and it is the responsibility of the user to create an output profile that makes sense for their application.

The only variables that are shared between the two outputs are: *Out Freq* and *Dither Freq*. However, *Dither Amp* can be independently adjusted for both outputs.
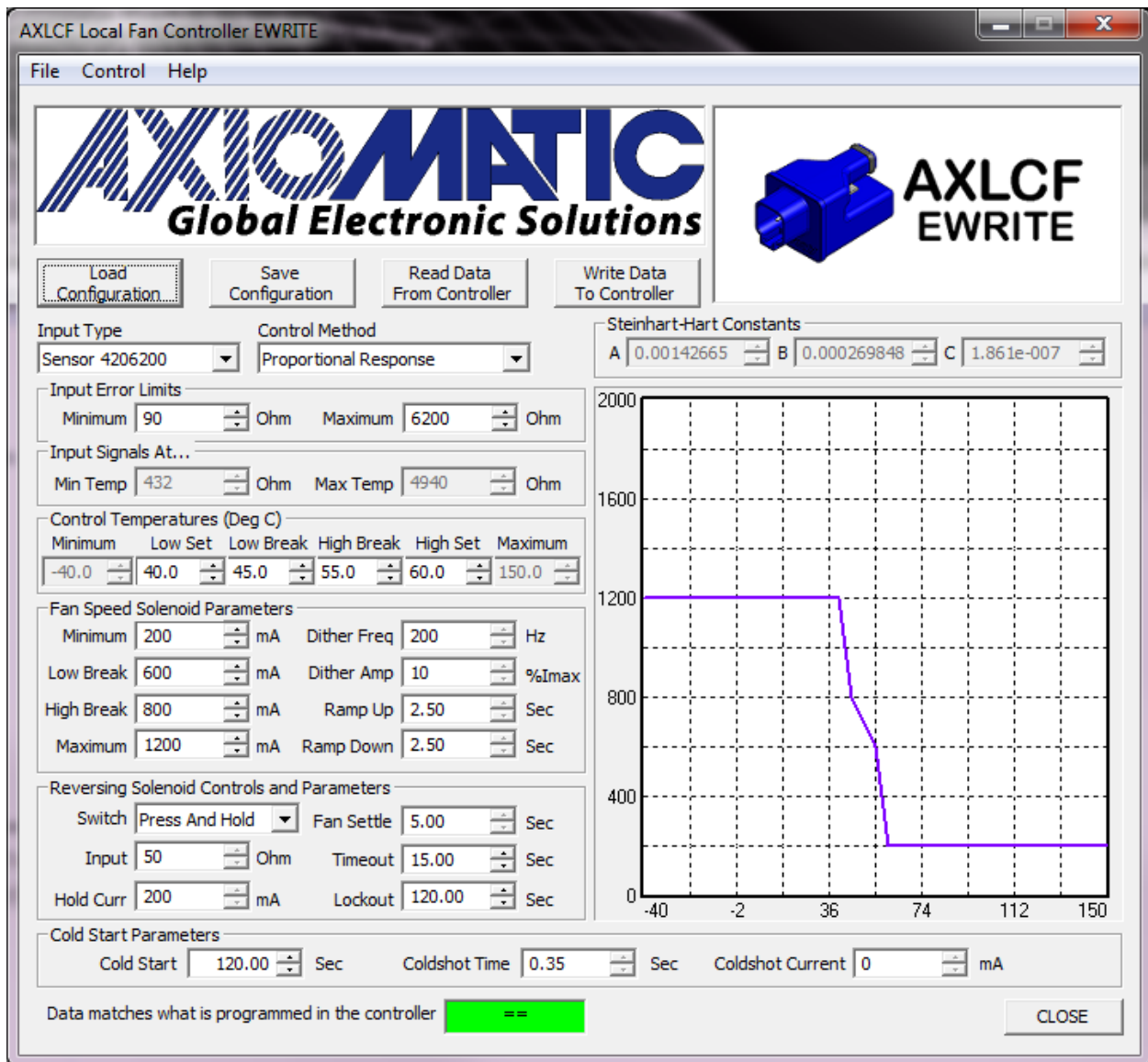
AXLCV Local Valve Controller EWRITE

File   Control   Help

AXIOMATIC
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AXLCV EWRITE

| Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller |

Input Type
0-5 Volt

Control Method
Independent Outputs

Input

	Minimum		Maximum	
Error	0.20	V	4.80	V
Range	0.50	V	4.50	V
Breakpoint	1.00	V	4.00	V
Deadband	2.30	V	2.70	V

Output

	Output 1		Output 2	
Type	Current		Current	
Minimum	200	mA	100	mA
Breakpoint	700	mA	700	mA
Maximum	2500	mA	2000	mA
Ramp Up	0	Sec	0.00	Sec
Ramp Down	0	Sec	0.00	Sec
Dither Amp	0	%Imax	0	%Imax

Out Freq 25000 Hz   Dither Freq 200 Hz

Data matches what is programmed in the controller   =/=

CLOSE

4. AXLCF Local Fan Controller Help

4.1. PINOUT

1 Reverse -
2 Signal -
3 Signal +
4 Power +
5 Power -
6 Reverse +
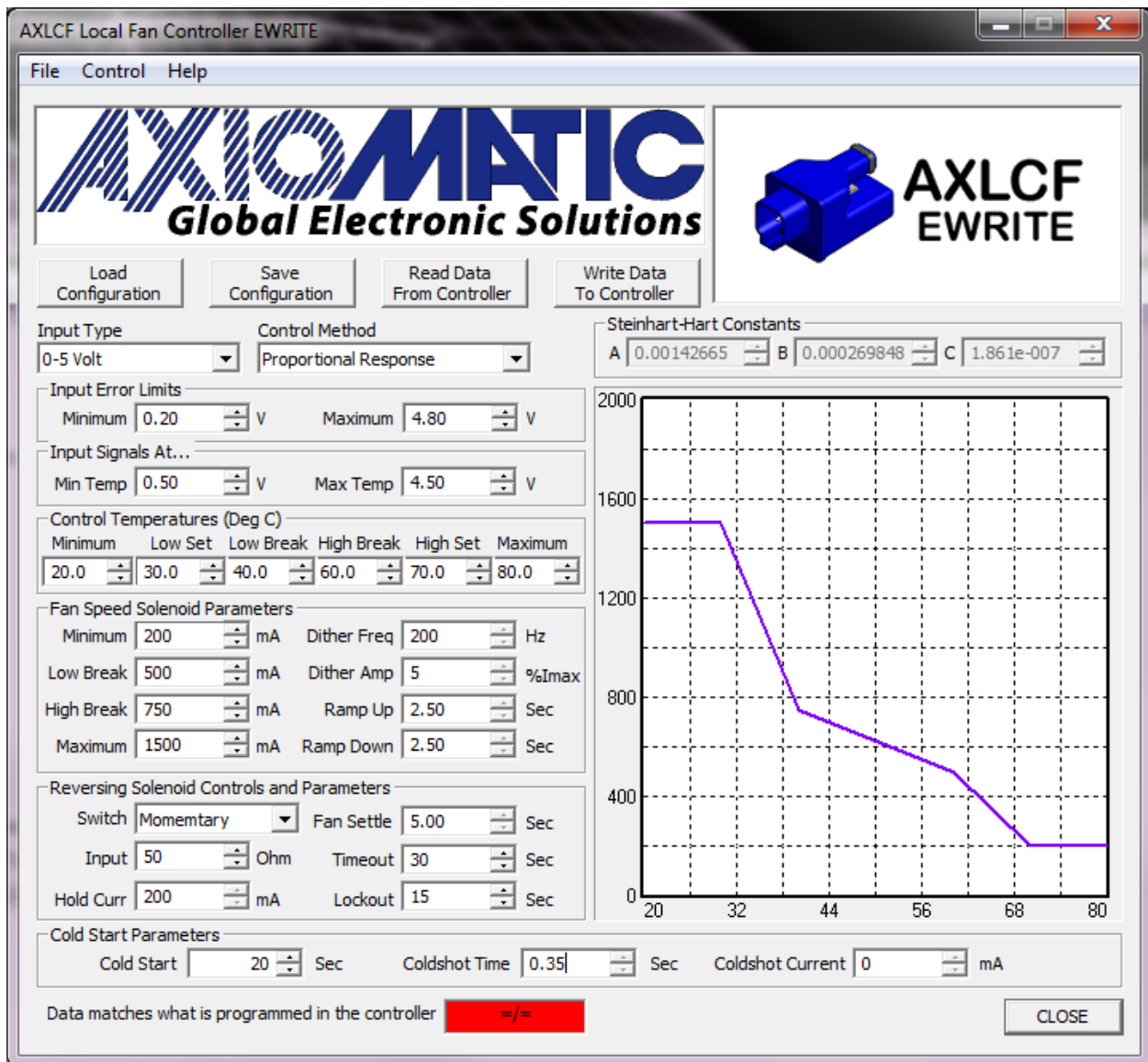
1 Fan Drive +
2 Fan Drive -

4.2. DEFAULTS

The screen capture below shows the **default** configuration of an AXLCF controller as received from the factory. In the case of the AXLCF controller type, the VIRTUAL UNIT defaults match those of the factory defaults.

AXLCF Local Fan Controller EWRITE

File   Control   Help

AXIOMATIC Global Electronic Solutions

AXLCF EWRITE

| Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller |

Input Type
Sensor 4206200 ▼

Control Method
Proportional Response ▼

Steinhart-Hart Constants
A 0.00142665   B 0.000269848   C 1.861e-007

Input Error Limits
Minimum 90 Ohm   Maximum 6200 Ohm

Input Signals At...
Min Temp 432 Ohm   Max Temp 4940 Ohm

Control Temperatures (Deg C)

Minimum	Low Set	Low Break	High Break	High Set	Maximum
-40.0	40.0	45.0	55.0	60.0	150.0

Fan Speed Solenoid Parameters

Minimum	200 mA	Dither Freq	200 Hz
Low Break	600 mA	Dither Amp	10 %Imax
High Break	800 mA	Ramp Up	2.50 Sec
Maximum	1200 mA	Ramp Down	2.50 Sec

Reversing Solenoid Controls and Parameters

Switch	Press And Hold ▼	Fan Settle	5.00 Sec
Input	50 Ohm	Timeout	15.00 Sec
Hold Curr	200 mA	Lockout	120.00 Sec

Cold Start Parameters
Cold Start 120.00 Sec   Coldshot Time 0.35 Sec   Coldshot Current 0 mA

Data matches what is programmed in the controller   ==

CLOSE

The example below shows the options available with a linear input type of input.

An important distinction to note between the two examples shown above is that on the first one, the bottom right hand corner shows the message "Data matches what is programmed in controller" with the synchronization box highlighted in green. However, on the second example, it shows that the data is not synchronized by the box showing red.

Any time after either the "Read Data From Controller" button or the "Write Data To Controller" button is selected, the program will communicate with the unit to read/write the variable configuration from/to the unit. As the program is communicating, the message under the graph will display the progress of the operation, as shown in the example below.

Once the program has successfully read/written the configuration, it knows that it has synchronized with the unit, and that it is correctly showing what the unit is doing. As soon as any variable has changed, it will update the message to remind the user that what they are seeing on the EWRITE tool does not match what is actually happening on the unit. Before testing the unit, a user should always make sure that the data shown on the tool matches what is in the unit by verifying the synchronization box is green.

Please note, with a *VIRTUAL UNIT* connection (selected from the main screen), the read/write buttons do not work, as the program assumes that no unit is connected.

4.3. INPUT TYPE

The controller supports a wide variety of *Input Type* options, as listed below. When changing the *Input Type*, all variables associated with the input are automatically updated for defaults that make sense for the selected type. The table below outlines the defaults for each type.

Type	Unit	Input Error Minimum	Input Signal at Min Temp	Input Signal at Max Temp	Input Error Maximum [3]
Non-Linear Resistive	[Ohm]	90	N/A [1]	N/A [1]	6200
Linear Resistive [5]	[Ohm]	90	100	5000	6200
PWM Duty Cycle [5]	[%]	5.0	20.5	79.5	95.0
0-5 Volt [5]	[V]	0.20	0.50	4.50	4.80
0-10 Volt [5]	[V]	0.20	0.50	9.50	9.80
4-20 Milliamp [5]	[mA]	1.50 [2]	4.0	20.0	21.0
Sensor 4206200	[Ohm]	100	432 [4]	4940 [4]	6200

For all input types, the following constraint applies: *Input Error Minimum <= Input Signal at Min Temp <= Input Signal at Max Temp <= Input Error Maximum*

Note 1, **Non-Linear Resistive** Type: The table below shows a typical temperature versus resistance curve for most thermistors. Since the relationship is standardized for most thermistors, with this type of input temperature is calculated from the resistance measured at the input using the Steinhart-Hart calculation. Instead of having a min and max limit, this type of input has three edit boxes for the A, B and C constants used in the calculation (see example of On/Off *Control Response* below). The third-order formula used to calculate the temperature is: $1/T = A + B \ln(R) + C \ln^3(R)$ where T is returned in Kelvin, then converted to Celsius by subtracting 273.15. To use this type of sensor, please contact the manufacturer of the thermistor to get the Steinhart-Hart constants that need to be entered.
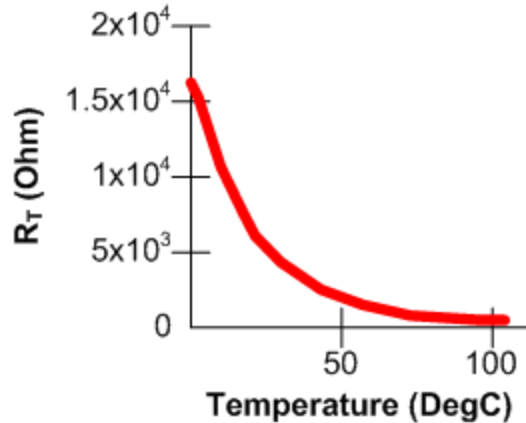
Note 2, **Input Error Minimum**: Setting the *Input Error Minimum* to zero will disable the error detection on the low end of the range. However, for current and resistive input types, the minimum error range is restricted to a non-zero value. In the case of the 4-20mA input type, the minimum error detection cannot be set lower than 1.5mA, and for a resistive input it is limited to 60 Ohms. The reason for this is that since communication with this configuration program is done through the same pin as the input, the unit needs to recognize when the communication adaptor (RS-232 to 1-wire) has been connected in order to turn off the current sense resistor (current types) or the current source (resistive types) to enable communication to be established. If error detection was disabled, the unit would be unable to ever re-connect to the computer.

Note 3, **Input Error Maximum**: For each type, the *Input Error Maximum* can be set higher than the range of the input (except for PWM) so that error detection at the upper end of the input range is disabled within the nominal input range. However, in all cases a short to +Vcc on the input would still cause the input to saturate, resulting in an error being flagged and the fan running at full speed (minimum current). The only exception for this is the PWM type, where setting the Error Max to 100% would disable the error detection fully, and the temperature would be calculated as being the *Max Temp* in the case of a short to +Vcc. For 0-5V, the error range is up to 5.5V, 0-10V up to 11.0V, current types up to 21mA, and resistive types up to 6200Ohm.

Note 4, **Sensor 4206200** Type: This is a custom input type supported by the unit which has a specific lookup table for the HydraForce sensor part number 4206200. Temperature is calculated from the measured resistance per the graph below, using a lookup table saved in the software of the unit. If the measured input is outside the valid range defined by the first and last entries of the table, the temperature will saturate high/low accordingly.

Temperature vs Resistance for Sensor 4206200
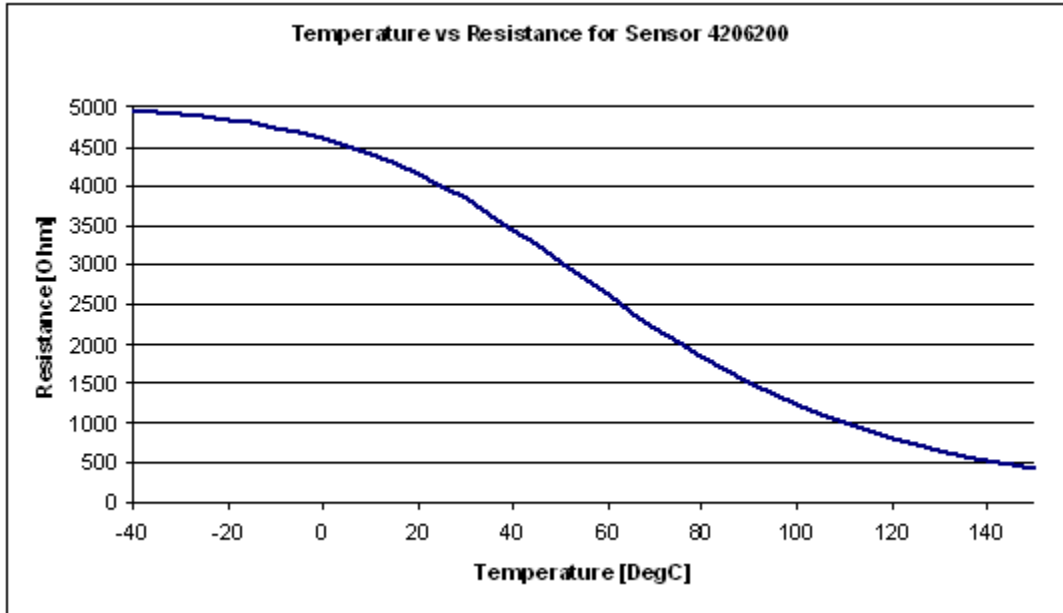
Note 5, **Linear Inputs**: In all cases, the measured input is converted into a temperature in degrees Celsius, which is in turn used to control the fan speed per the algorithms described below. Other than the two non-linear input types described in the notes above, all other inputs are converted to a temperature using a linear calculation where the slope and offset are calculated per the following formula:

$T = m * R + b$, where m (slope) = (Ymax - Ymin)/(Xmax - Xmin) and b = Ymin - m*Xmin

In this case, Xmin = *Input Signal at Min Temp* and Xmax = *Input Signal at Max Temp*, while Ymin = *Control Temperature Minimum* and Ymax = *Control Temperature Maximum*

If the measured input is below the minimum or above the maximum input range, the temperature will saturate low/high accordingly.

For the *Linear Resistive* type, the allowable input range is 100 to 6000 Ohms.

4.4.   CONTROL METHOD

As explained above, regardless of the *Input Type* selected, all measurements are converted to a temperature in degrees Celsius before being used in the control algorithm. There are two different *Control Methods* supported by the AXLCF to determine how the Fan output will respond to temperature changes.

Proportional Response
On/Off Response

4.4.1. Proportional Response

The first type is a ***Proportional Response***, examples of which are shown in the screen captures at the top of this page. With this response, the fan speed will vary linearly with up to three different slopes available throughout specified temperature ranges. For the ***Control Temperatures***, the following constraint applies:

Minimum <= Low Set <= Low Break <= High Break <= High Set <= Maximum

The AXLCF Local Fan Controller is designed to work ONLY with inverse fans. This means that the higher the current through the coil, the slower the fan will be running. Therefore, in the ***Fan Speed Solenoid Parameters*** category, the output current controls have the follow constraint:

Minimum <= Low Break <= High Break <= Maximum

In the case of a inverse fan, the *Minimum* current should correspond to full fan speed while the *Maximum* current is assumed to put the fan into an idling state. The *Minimum* current can be set down to 0mA, while the *Maximum* can be adjusted up to 3000mA.

With a *Proportional Response*, temperatures between the *Low Set* and *Low Break* values will have the output decrease linearly between the *Maximum* and *High Break* currents, while temperatures between the *Low Break* and *High Break* controls will use the slope calculated by the *High Break* and *Low Break* currents. Finally, warmer temperatures between the *High Break* and *High Set* control values will decrease the output proportionally between the *Low Break* and *Minimum* currents.

The *Minimum* and *Maximum* control temperatures are not actually used in the control logic, but are used instead with the input to temperature calculations described above in the **Input Type** section. With a *Proportional Response,* any temperature below the *Low Set* control temperature will simply cause the fan to idle, while any temperature over the *High Set* value will have the fan running at full speed.

The other variables associated with the fan solenoid are dealing with dither and ramping of the current. The *Dither Freq* and *Dither Amp* boxes determine if dithering will be applied to the output, and if so at what frequency and amplitude. The exact amplitude and frequency of the dither will depend partly on the properties of the coil itself, so the numbers will not necessarily be exact. The intent of having a low-frequency dither superimposed on top of the high frequency drive signal used to regulate the current through the load is to enable the valve to respond to minute changes in the current. It is meant to overcome the effects of static friction in the valve, so it should be optimized for the load to get the best results in system. A large enough amplitude should be selected to enable smooth responses, but not so large that it de-stabilizes the output accuracy.

Dither Amp (amplitude) is defined as a percentage of the *Maximum* current and can be set between 0 to 50%. Please note, setting it to 0% disables the dither.

Dither Freq (frequency) can be set between 50Hz to 400Hz

The *Ramp Up* variable determines how long it would take to ramp from zero to *Maximum* current assuming a step change at the input. It is also used to ramp the fan from full to idle speed in the reversing profile described below. The *Ramp Down* variable determines how long it would take to ramp from *Maximum* current to zero assuming a step change at the input. It is also used to ramp the fan from idle to full speed in the reversing profile described below. Both ramps are fully independent of one another, and can be set anywhere from 0 to 60 seconds, where zero disables the ramp.

4.4.2.   On/Off Response

The other type of control is an **On/Off Response**, an example of which can be seen below. With this type of control, the fan is not responding linearly to temperature changes, but will step to different currents (speeds) as the temperature goes above or below a certain threshold. Note: when non-zero ramps are used, the current will not step as shown in the image below, but rather ramp up/down to the next level at the appropriate rate.

The image below shows that there is hysteresis built in to the step changes, and the output current will change differently depending on if the temperature is increasing or decreasing.
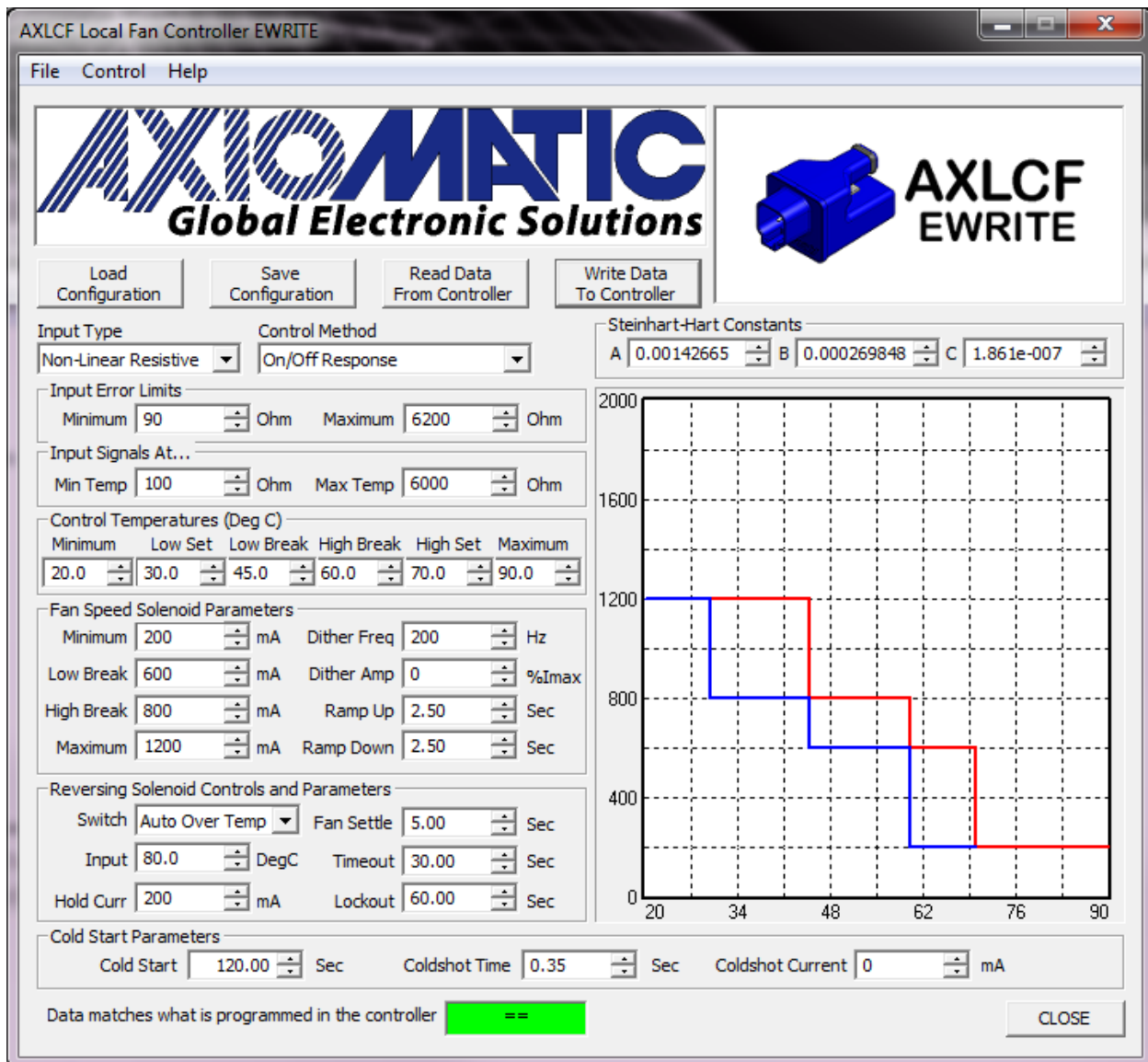
For increasing temperatures, the red trace applies. Here, the output will drop to the *High Break* current (fan will stop idling) when *Temp Low Break* <= Tmeas < *Temp High Break*. The next step occurs when *Temp High Break* <= Tmeas < *Temp High Set* and the output drops to the *Low Break* current. Finally, the current will drop to its *Minimum* (fan at full speed) when the temperature is greater than or equal to the *Temp High Set* threshold.

For decreasing temperatures, the blue trace applies. Once the output has dropped to a lower current and the fan is running at a faster speed, the fan will not slow down until the temperature has cooled below the initial temperature that sped it up. If it as running *Minimum* current (full speed), the fan will slow down by jumping to the *Low Break* current when *Temp Low Break* < Tmeas <= *Temp High Break*. It will continue to slow by jumping to the *High Break* current when *Temp Low Set* < Tmeas <= *Temp Low Break*.

Finally, the current will return to its *Maximum* (fan idling) only when the temperature is less than or equal to the *Temp Low Set* threshold.

The profile below shows how the current changes differently with respect to increasing and decreasing temperature changes.

I/O Response Over Time

Control Temperatures (DegC): Maximum, High Set, High Break, Low Break, Low Set, Minimum

Fan Speed Solenoid [mA]: Maximum (Idle Speed), High Break, Low Break, Minimum (Full Speed)
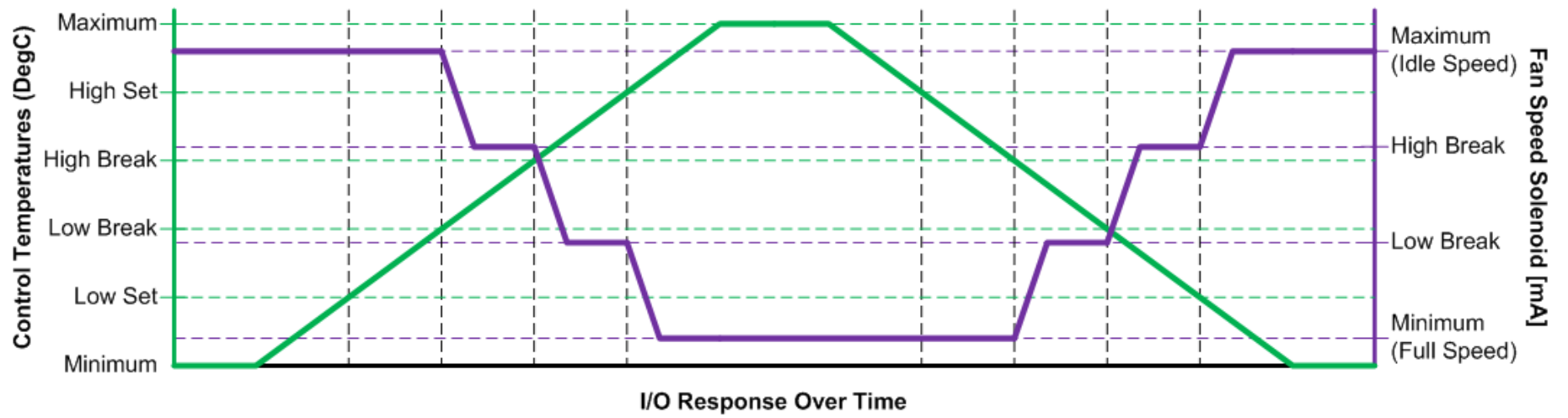
4.5. COLD START

As stated earlier, if the measured input is outside of the error limits for the type, the controller will run the fan at full speed. However, with a thermistor input at very cold temperatures, the resistance of the sensor can be very high, as shown by the graph of a typical thermistor T vs R curve in the *Input Type* section. Since the actual resistance could be higher than the maximum range of measurement for the AXLCF of 6200 Ohm, the fan would be running at full speed, even though the vehicle is very cold.

To avoid this scenario, there is a parameter called *Cold Start* that will keep the fan idling, even if the input is out of range at power up. This allows the vehicle enough time to warm up to the measurable temperature range without having the fan run. As soon as the input measures within a valid range for at least 100ms, the unit will stop the Cold Start timer, and respond as per normal operation. If the input goes out of range after this point, the fan will default to the normal error response of running the fan at full speed.

The *Cold Start* timer can be set anywhere from 1 to 900 seconds (15 minutes.)

4.6. COLD SHOT AND HOT SHOT

A cold shot is defined as bringing the current through the coil to a very low value (default 0mA) for a short period of time, to allow the valve to open properly and respond to the higher currents. At power-up, the first time a non-idle speed is required, the unit will cold shot the current to the solenoid before ramping to the desired current. If ten seconds after power is first applied to the unit, assuming that the unit is not idling because of a cold start, or that it has not started running at a lower current because of a higher temperature, the output will automatically have a cold shot applied to 'kick' open the valve so that it will respond with small current steps as the temperature starts to increase. Also, any time the unit comes out of a reverse cycle, it will cold shot the output before ramping to the current required by the temperature.

The program allows the user to adjust both the *Coldshot Curr* and the *Coldshot Time* as desired. The current can be set anywhere in the range of 0mA to 3000mA, while the time can be set from 0 to 5 seconds.

A hot shot is the opposite of a cold shot, and for the AXLCF application is only applicable for the Reverse Solenoid as it is normally OFF unless current is driving it open. In the case of the reverse valve, when it is first turned ON, it is fully opened by applying 3000mA to the coil for 1 second. (The level and time are fixed in the software.) It will then drop to the *Rev Hold Curr* output value, which is user configurable between 0 to 3000mA. The hold current should be high enough to ensure the coil remains engaged while the fan is in reverse mode, but low enough that it does not waste energy to hold open the on/off valve.

4.7.   REVERSING

The remaining variables for the AXLCF that have not yet been discussed are all related to reversing the fan to allow it to blow debris out of the radiator. The first variable for **Reversing Solenoid Controls and Parameters** is the type of input that would be used to reverse the fan. The options for the *Switch* are

| Press and Hold (i.e. toggle switch) |
| Momentary (i.e. push button) |
| Auto Over Temp (i.e. no switch required) |

All three inputs control how the reversing happens in subtly different ways, as shown in the profiles below. Before elaborating on that, however, the *Input* parameter must be understood. For a switch input, the unit will see the switch as being closed (ON) whenever the resistance at the input pin measures between 20 Ohm to *Input* (default 50) + 10 Ohm. It is recommended to wire an accurate, low value resistor in parallel to the input pin through the switch as shown in the figure below. The resistor must match what is programmed as the *Input* value for the reversing switch.
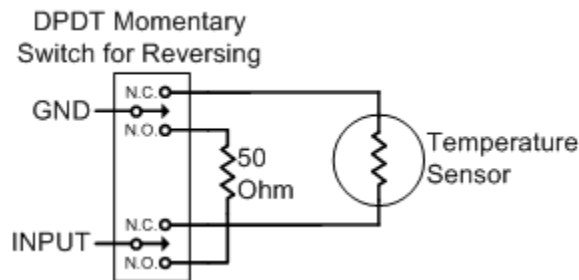
The image above shows a typical wiring circuit for a resistive input (i.e. a thermistor) so the current source to read resistive inputs is already enabled by default for that type of sensor. When a non-resistive input is used, the wiring would be the same, but the "Temperature Sensor" in the picture would simply be replace with the voltage, current or PWM source. In these cases, when the input measures out of range (i.e below the Input Error Limits *Minimum*) the unit will automatically turn on the current source to see if a resistive load has been connected instead. If the reverse switch is ON connecting the resistor to the input, the AXLCF will recognize the switch is ON and start the reverse sequence accordingly.

In all cases, a reverse cycle consists of the following steps

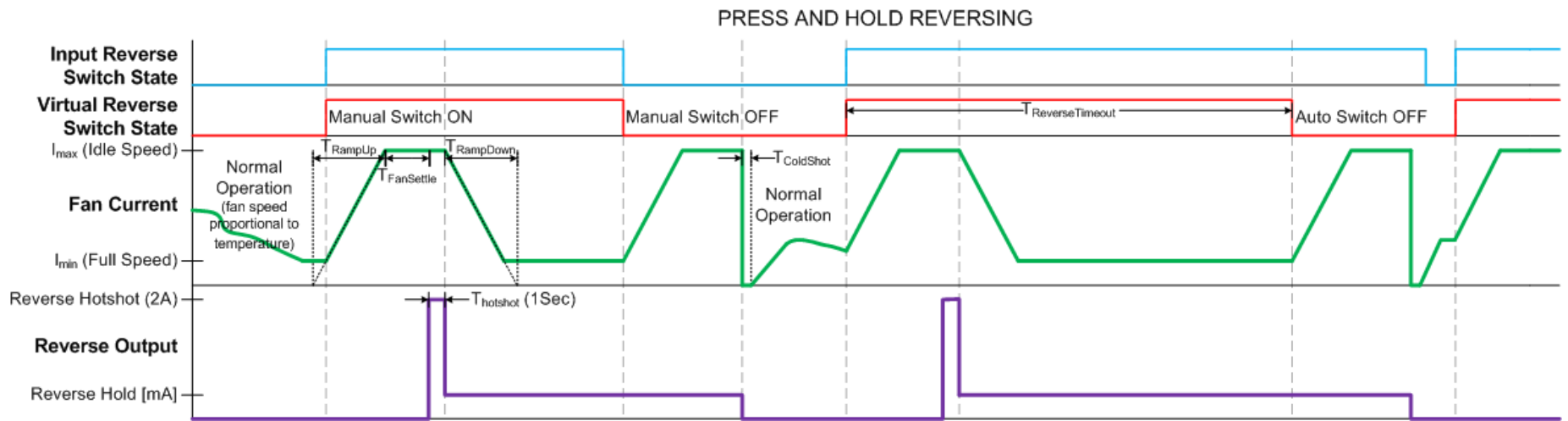| **TURN REVERSE ON** |
| Ramp current up to *Maximum* current (idling) at *Ramp Up* rate |
| Let the fan slow down (i.e come to full idle) for *Fan Settling* time |
| Turn ON the reverse output (recall it will have the hotshot current applied for the hotshot time before dropping to the *Rev Hold Curr*) |
| Ramp current down to *Minimum* current (full speed) at *Ramp Down* rate |

Fan runs at full speed in reverse until either the switch is turned off, or the *Timeout* elapses
TURN REVERSE OFF
Ramp current up to *Maximum* current (idling) at *Ramp Up* rate
Let the fan slow down (i.e come to full idle) for *Fan Settling* time
Turn OFF the reverse output
Set the fan output to the *Coldshot Curr* for the *Coldshot Time*
Ramp current up at *Ramp Up* rate to the value required by the temperature, and restart normal operation

Note: If the reverse cycle is interrupted before it can be completed (i.e. the reverse switch turns OFF), if the reverse output has not yet been engaged (i.e. in the ramping or settling portion of the reverse profile) the output will be cold shot, and resume normal operation immediately.

As stated earlier, there are subtle but important differences for each switch type. It is important to understand the distinctions, so that each parameter can be adjusted appropriately.

With the **Press And Hold** *Switch* type the virtual reverse switch state (i.e. the command to turn reversing on or off) mostly mirrors the state of the actual input, as shown below. The only difference is if the input switch is not disengaged before the reverse *Timeout* elapses, reversing will shutoff automatically even if the switch is still on. If this happens, as soon as the switch turns off then back on, another reverse cycle will begin immediately. In this case, the parameter *Reverse Lockout* is not used.

As can been seen from the second reverse cycle shown in the image below, the reverse *Timeout* starts counting down as soon as the reverse input is first engaged. Therefore, the *Timeout* period should always include not only the time for the fan to run at full speed in reverse, but also the time needed for *Ramp Up*, *Fan Settling*, and *Ramp Down* combined. It can be set anywhere between 1 to 120 seconds (2 minutes.) Fan Settling on the other hand can be set between 0 to 60 seconds (1 minutes.)

PRESS AND HOLD REVERSING

Input Reverse Switch State

Virtual Reverse Switch State

Manual Switch ON — Manual Switch OFF — $T_{ReverseTimeout}$ — Auto Switch OFF

I_{max} (Idle Speed)

T_{RampUp} — $T_{FanSettle}$ — $T_{RampDown}$ — $T_{ColdShot}$

Fan Current

Normal Operation (fan speed proportional to temperature)

Normal Operation

I_{min} (Full Speed)

Reverse Hotshot (2A)

$T_{hotshot}$ (1Sec)

Reverse Output

Reverse Hold [mA]

With the **Momentary** *Switch* type the virtual reverse switch state will turn ON when the switch is active for more than the digital debounce period (fixed at 50ms). If the switch is turned OFF then back ON again within the *Reverse Lockout* period, the input state change will have no effect. However, should the switch transition from OFF to ON after the lockout has elapsed, the reverse cycle will be turned off. Once the reverse cycle started, if the switch is not activated again within the *Timeout* period, reversing will be shutoff automatically.

As shown at the last part of the image below, if the momentary switch is held down for more than the *Reverse Lockout* period, the reverse cycle will shutdown, and the fan will run at full speed because the AXLCF will be reading an error at the input. Therefore, for this type of switch, the lockout period should be set long enough so as to not timeout while the switch is depressed for the first time, but short enough that the operator would be able to manually turn off the reversing after a nominal period of time. A reasonable number would probably be anything from 5 to 10 seconds, but the user would have to set this as appropriate for their application.

MOMENTARY SWITCH REVERSING
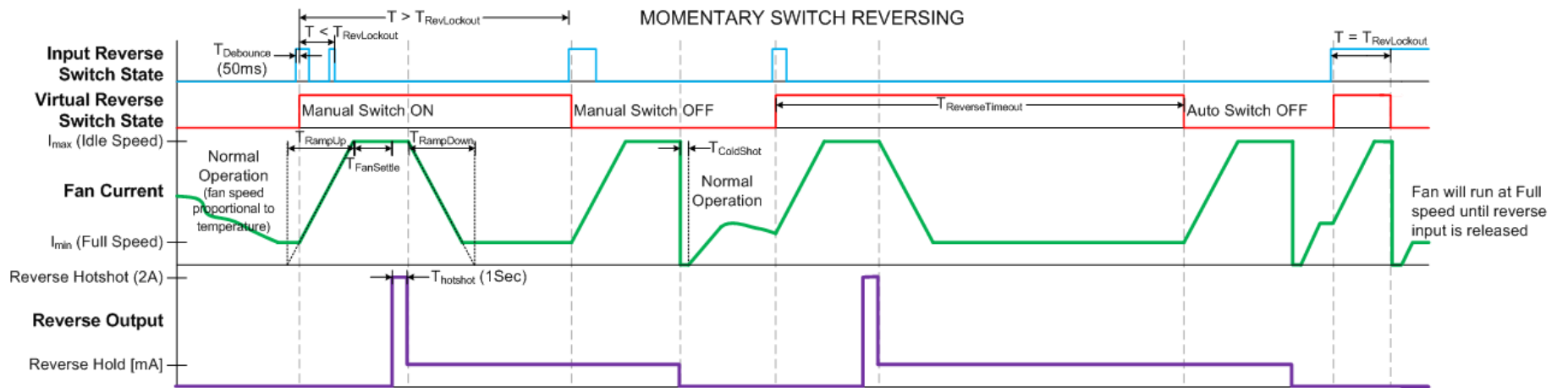
The last *Switch* type is the **Auto Over Temp**. In this case, a resistive input will not be switched across the input, but rather the fan will automatically reverse when the measured temperature exceeds the *Input* value in Deg C. (See the On/Off Response screen capture for an example of this type of reverse switch.) Here, the reverse cycle will be turned off ONLY by the *Timeout* period elapsing. As shown in the example below, even though the temperature of the fan might decrease below the *Input* value during the reverse cycle, it still continues. Once a reverse cycle has occurred, another one will not take place until the *Reverse Lockout* period has elapsed. This is true even if the temperature rises above the *Input* threshold during the lockout period, as shown in the example below. For this reason, the *Reverse Lockout* should be set for a relatively long time to prevent the fan from only running in reverse under hot conditions. By default it is set to 120 seconds (2 minutes) but it can be adjusted anywhere from 1 to 900 seconds (15 minutes.)

OVER TEMPERATURE REVERSING
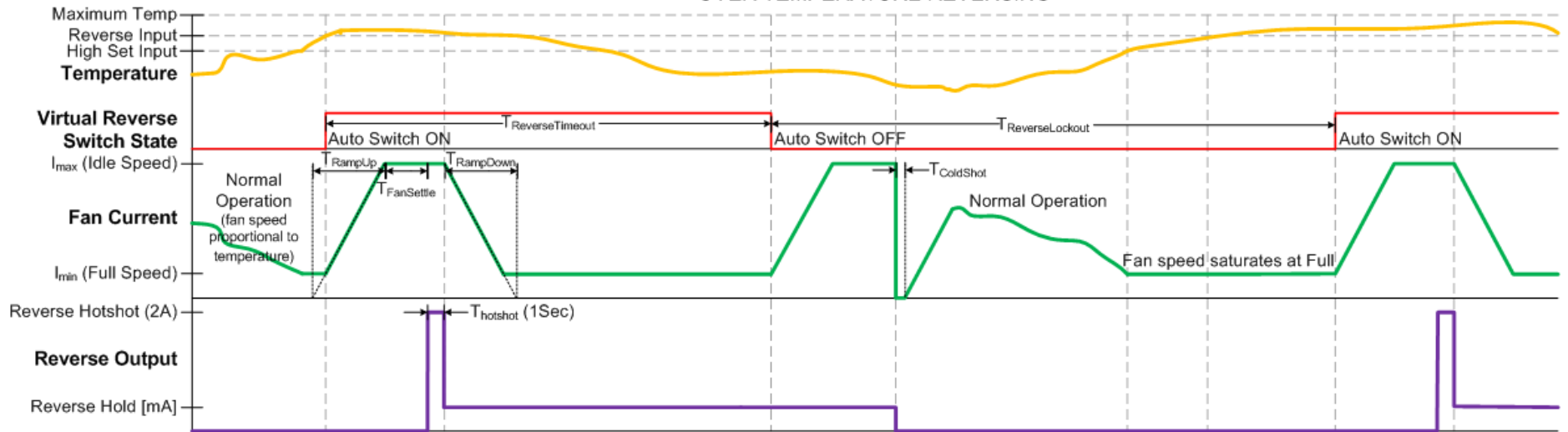
5. AXLTC Local Transmission Controller Help
5.1. PINOUT

1 Reverse -
2 Signal -
3 Signal +
4 Power +
5 Power -
6 Reverse +
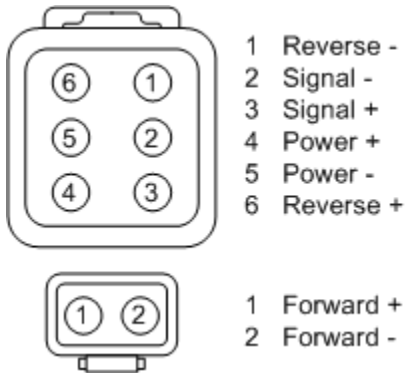
1 Forward +
2 Forward -

5.2. DEFAULTS
The screen capture below shows the **default** configuration of an AXLCT controller as received from the factory. In the case of the AXLCT controller type, the VIRTUAL UNIT defaults match those of the factory defaults.
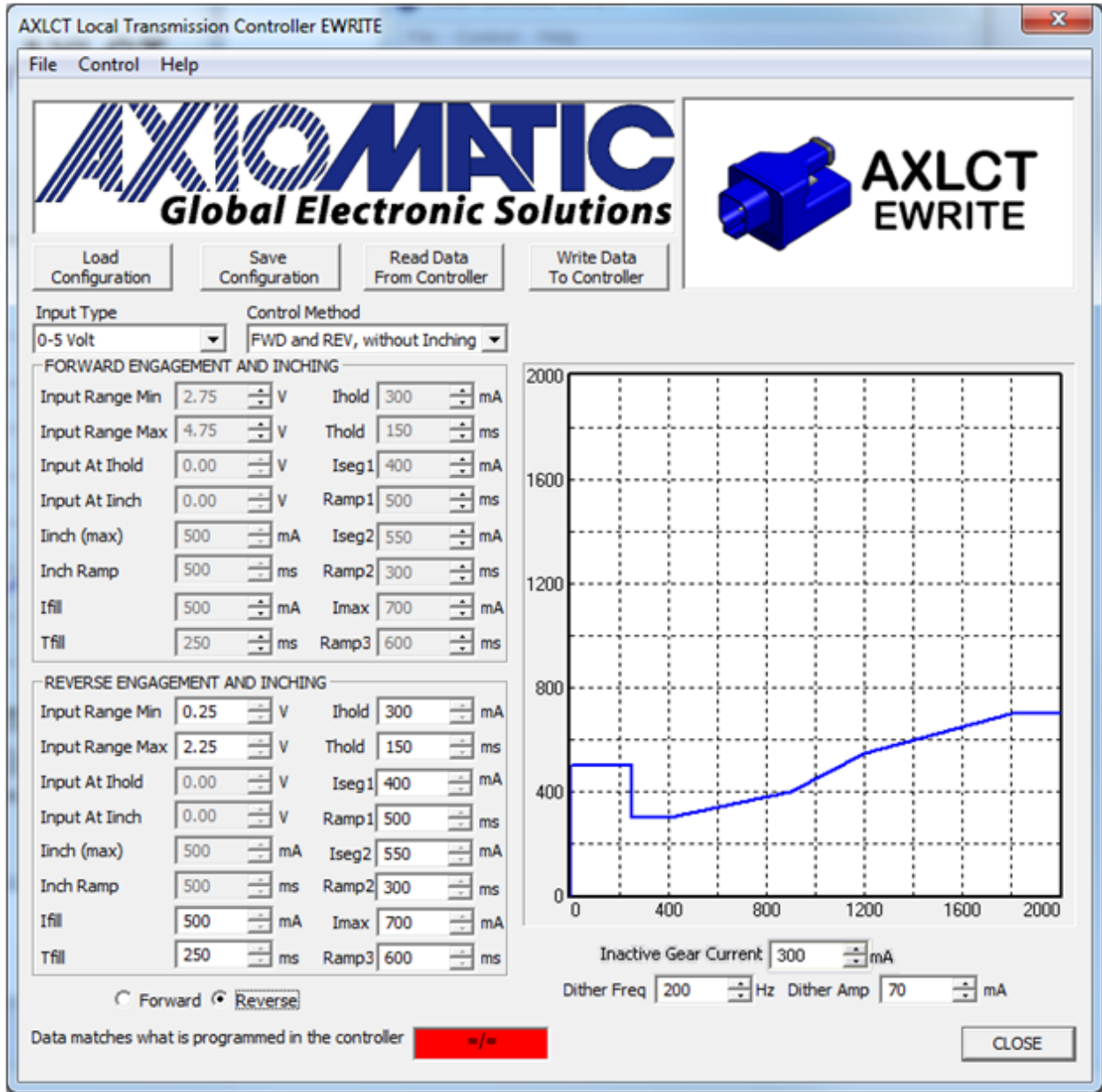
5.2.1. Forward Screen
By default, the AXLCT unit is setup to only drive a Forward coil.
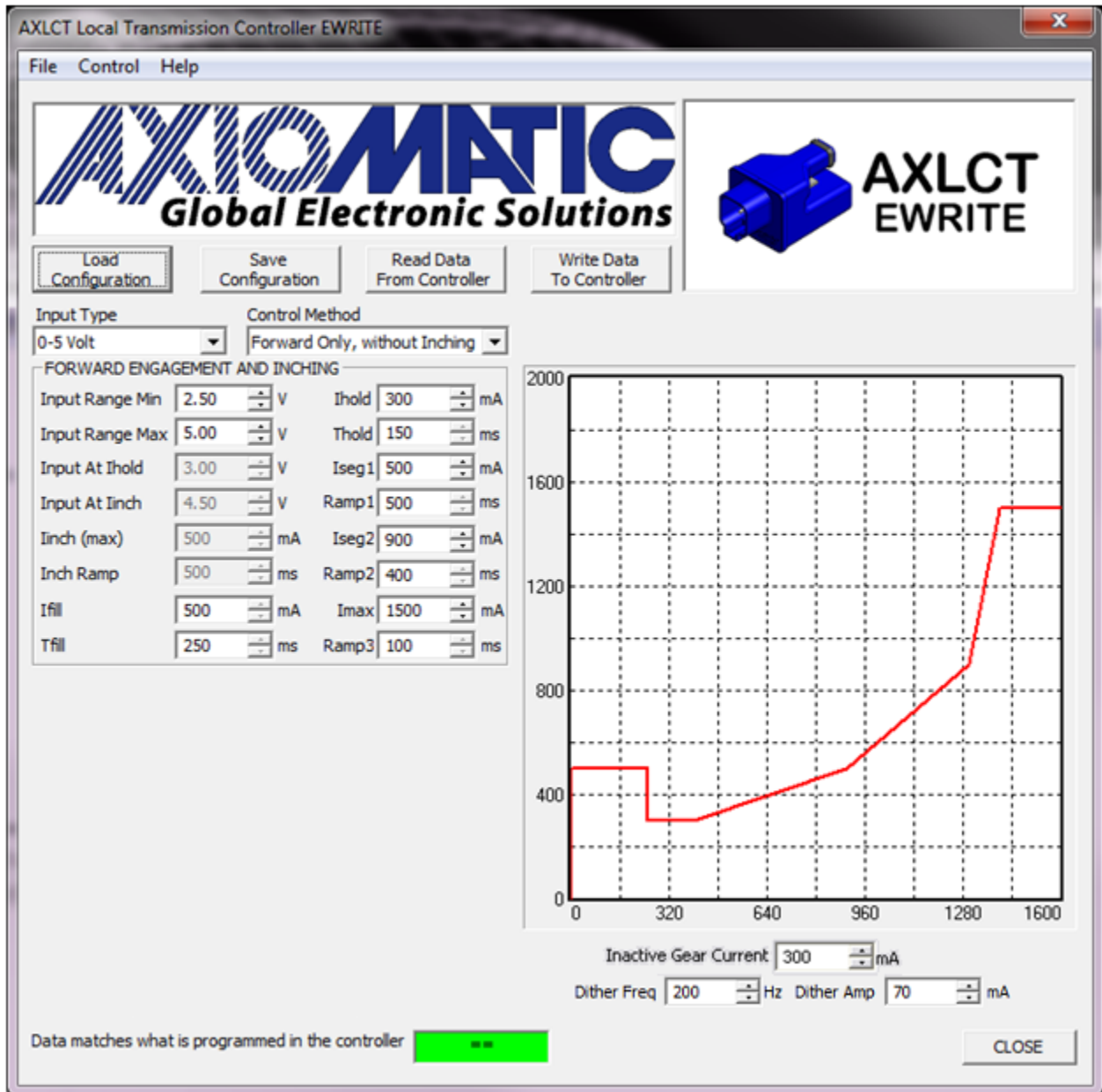
5.2.2. Reverse Screen

This screen capture shows a reverse profile which becomes enabled only when the *Control Method* is changed for a FWD and REV response.

An important distinction to note between the two examples shown above is that on the first one, the bottom right hand corner shows the message "Data matches what is programmed in controller" with the synchronization box highlighted in green. However, on the second example, it shows that the data is not synchronized by the box showing red.

Any time after either the "Read Data From Controller" button or the "Write Data To Controller" button is selected, the program will communicate with the unit to read/write the variable configuration from/to the unit. As the program is communicating, the message under the graph will display the progress of the operation, as shown in the example below.

Data matches what is programmed in the controller | =/= | .... | CLOSE

Once the program has successfully read/written the configuration, it knows that it has synchronized with the unit, and that it is correctly showing what the unit is doing. As soon as any variable has changed, it will update the message to remind the user that what they are seeing on the EWRITE tool does not match what is actually happening on the unit. Before testing the unit, a user should always make sure that the data shown on the tool matches what is in the unit by verifying the synchronization box is green.

Please note, with a VIRTUAL UNIT connection (selected from the main screen), the read/write buttons do not work, as the program assumes that no unit is connected.

5.3. INPUT TYPE

The AXLCT controller supports a wide variety of *Input Type* options, as listed below. When changing the *Input Type* , all variables associated with the input are automatically updated for defaults that make sense for the selected type. The table below outlines the defaults for each type

Type	Unit	REV Input Range Min	REV Input At Iinch	REV Input At Ihold	REV Input Range Max	FWD Input Range Min	FWD Input At Ihold	FWD Input At Iinch	FWD Input Range Max	Hysteresis (fixed by type)
PWM Duty Cycle	[%]	5.0	10.0	40.0	45.0	55.0	60.0	90.0	95.0	1.0
0-5 Volt	[V]	0.25	0.50	2.00	2.25	2.75	3.00	4.50	4.75	0.10
0-10 Volt	[V]	0.50	1.00	4.00	4.50	5.50	6.00	9.00	9.50	0.10
4-20 Milliamp	[mA]	4.0	6.0	8.0	11.0	13.0	16.0	18.0	20.0	0.25
Resistive 0-5kOhm	[kOhm]	0.25	0.50	2.00	2.25	2.75	3.00	4.50	4.75	0.10
Fill at Powerup	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

In all cases (except the last), if the input measures below or above the range for a particular output (FORWARD or REVERSE), the output will be OFF. If the input is not within either output's valid ranges, both outputs will be off, and the unit will be in NEUTRAL.

The "Fill at Powerup" is a special case where the input type is irrelevant. In this case the AXLCT performs like a "soft shift" controller, and will engage the FORWARD gear immediately when power is first applied to the unit, regardless of what type of signal is applied at the input.

5.4.   CONTROL METHOD

The *Control Method* determines how the output(s) will respond to changes at the input. There are four options, listed below.

Forward Only, without Inching
Forward Only, with Inching
FWD and REV, without Inching
FWD and REV, with Inching

5.4.1.   Forward Only, without Inching

For the first option **Forward Only, without Inching** (see first screen capture of default settings), the control logic is very simple. In this case, the output will be turned ON when *Input Range Min* <= Imeasured <= *Input Range Max.* When first turning on, the output will follow the profile shown in the graphical portion of the programmer. Once the output current has reached the *Imax* value, it will stay there until the measured input goes outside of the range, at which point the output current will immediately drop to zero.

For this type of *Control Method*, the following input constraint applies: *Input Range Min <= Input Range Max*

For each gear, the parameters in the left hand column relate to the input and inching, while those on the right relate to the transmission shift profile.

In all cases, *Ifill* is unconstrained, and can be set anywhere from 0 to 3000mA. However, *Ihold* must always be less than or equal to Iseg1 which must always be less than or equal to Iseg 2 which must always be less than or equal to *Imax*. Therefore, the following output current constraint applies 0mA <= *Ihold* <= *Iseg1* <= *Iseg2* <= *Imax* <= 3000mA.

The timing parameters are fully independent from one another so *Tfill, Thold, Ramp1, Ramp2* and *Ramp3* can each be set anywhere from 0 to 10,000ms. *Tfill* determines how long the output current will stay at the *Ifill* level when the output is first turned on (i.e. coming out of NEUTRAL) Similarly, the *Ihold* current is held for the *Thold* time. The *Ramp1* time defines how long it will take for the output current to ramp from the *Ihold* to *Iseg1*. *Ramp2* time defines how long it will take for the output current to ramp from the *Ihold* to *Iseg2*. *Ramp3* time defines how long it will take for the output current to ramp from the *Ihold* to *Imax* level. Another parameter is *Inactive Gear Current* which allows the user to select a bias current to keep the output(s) driven when the controller is in NEUTRAL gear or when any of the two gears (FORWARD or REVERSE) is inactive. The range of *Inactive Gear Current* is from 0 to 3000mA.

In the Forward or Reverse graphs, the X-axis represents time and will change as these variables are adjusted. In all graphs, the Y-axis always represents the output current.

The other variables available with all types of control are the *Dither Freq* and *Dither Amp* boxes at the bottom right hand corner. These variables determine if dithering will be applied to the output, and if so at what frequency and amplitude. The exact amplitude and frequency of the dither will depend partly on the properties of the coil itself, so the numbers will not necessarily be exact. The intent of having a low-frequency dither superimposed on top of the high frequency drive signal used to regulate the current through the load is to enable the valve to respond to minute changes in the current. It is meant to overcome the effects of static friction in the valve, so it should be optimized for the load to get the best results in system. A large enough amplitude should be selected to enable smooth responses, but not so large that it de-stabilizes the output accuracy.

Dither Amp (amplitude) can be set between 0 to 500mA. Please note, setting it to 0mA disables the dither.

Dither Freq (frequency) can be set between 50Hz to 400Hz

5.4.2. Forward Only, with Inching

The second control option **Forward Only, with Inching** has all the same variables available as described above. However, in this case there are two buttons available under the graph to determine if it will display the "Forward" or "Inch/Troll" profile. When the "Forward" button is selected, all of the input and inching variables in the left hand column are grayed out. Here, only the output current and timing variables are available to change the transmission shift profile.

To adjust the input or inching parameters, select the "Inch/Troll" button under the graph. In this case, the parameters in the left hand column are enabled, while all the output variables on the right are grayed out except the *Ihold* and *Imax* .

In this control mode, the following output current constraint applies 0mA <= *Ihold* <= *Iinch (max)* <= *Imax* <= 3000mA.

While the input range constraint *Input Range Min* <= *Input Range Max* still applies, the *Input At Ihold* and *Input At Iinch* both have to fall within this range, but are otherwise not related to one another. The graphs below show how the inching response could be setup for either a positive or negative slope depending on which parameter is set higher than the other.

When the input is within the range defined by the [*Input At Ihold,Input At Iinch*] parameters, the current through the solenoid will be linearly proportional to the input. When shifting from NEUTRAL (i.e. input was out of range) the shift profile will always apply, so the output will first be turned on to the *Ifill* value, then drop to *Ihold*, and then *Ramp* to the current level required by the input while in the inching range.

For the positive slope response shown in the left hand image below, note that in this case *Input At Ihold* has been set equal to *Input Range Min.* The reason for this is that

when *Input At Ihold > Input Range Min*, the graph shows the output as staying at *Ihold* between those two points. However, this condition is only true when the AXLCT is already in Inching mode, and the input goes below the *Input At Ihold* value. If the input is increasing, that is it was below the *Input Range Min* limit (i.e. in NEUTRAL) then it crossed it putting the gear into FORWARD, the output will simply follow the normal shift profile and end up at the *Imax* value. Setting *Input At Ihold = Input Range Min* prevents this potentially undesirable response from occurring.

The same point holds true for the negative slope response shown in the right hand image below, but this time relating to the range between *Input At Ihold* and *Input Range Max.* In this case, as the input increases, the output current will stay at *Ihold* if the input goes past the *Input At Ihold* threshold, as shown in the graph. However, if the input is decreasing, that is it was above the *Input Range Max* limit (i.e. in NEUTRAL) then it crossed it putting the gear into FORWARD, the output will simply follow the normal shift profile and end up at the *Imax* value. To prevent this, the solution would be to set *Input At Ihold = Input Range Max.*

In the instances where the controller is in the NEUTRAL gear or when any of the two gears (FORWARD or REVERSE) is inactive, *Inactive Gear Current* allows the user to select at what current to keep the output every time it is in NEUTRAL or inactive.

The transmission controller allows for the gears to be reversed in the case of **FWD and REV, without Inching** and **FWD and REV, with Inching** by adjusting the *Input Range Min* and *Input Range Max* of the Forward and Reverse engagements. This will be explained in more details in their respective section below.
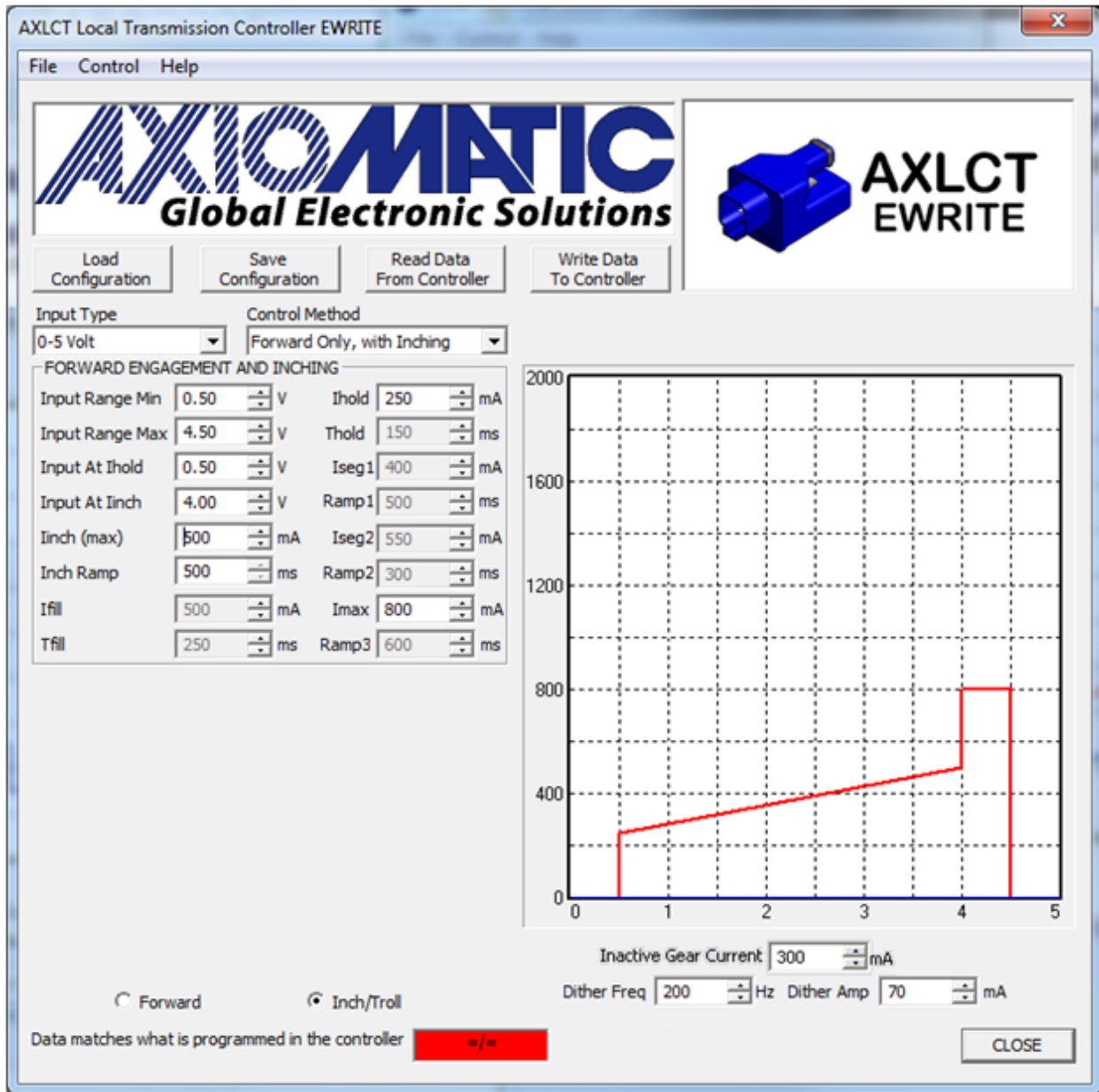
5.4.3. FWD and REV, without Inching

The third control option **FWD and REV, without Inching** is very similar in behaviour to *Forward Only, without Inching*.

In this case, the FORWARD output will be turned ON when *Input Range Min* <= Imeasured <= *Input Range Max* from the FORWARD ENGAGEMENT AND INCHING box. When first turning on, the output will follow the profile shown in the graphical portion of the programmer. Once the output current has reached the *Imax* value, it will stay there until the measured input goes outside of the range, at which point the output current will immediately drop to zero. As long as the input is less than *Input Range Min* or greater than *Input Range Max* the FORWARD output will be OFF.

Similarly, the REVESE output will be turned ON when *Input Range Min* <= Imeasured <= *Input Range Max* from the REVERESE ENGAGEMENT AND INCHING box. As long as the input is less than *Input Range Min* or greater than *Input Range Max* the REVERSE output will be OFF.

The parameters associated with the Forward or Reverse gear are only available to be edited when the button below the graph has been selected for the desired gear.

For this type of *Control Method*, the following is the default input constraint that applies:

Reverse *Input Range Min* <= Reverse *Input Range Max* <= Forward *Input Range Min* <= Forward *Input Range Max*

However, this constraint can be reversed if the following input adjustment occurs such that:

Forward *Input Range Max* <= Reverse *Input Range Max* <= *Input Max*

If the above occurs, then the constraint becomes:

Forward *Input Range Min* <= Forward *Input Range Max* <= Reverse *Input Range Min* <= Reverse *Input Range Max*

The output current levels and engagement timing parameters behave the same as described in the *Forward Only, without Inching* section.

5.4.4.   FWD and REV, with Inching

The last control option is the ***FWD and REV, with Inching*** and it is the most complicated of the four output profiles. The profile for FORWARE or REVERSE engagement when the selected gear is first turned ON is identical to that described in the *FWD and REV, without Inching* above.

For this type of *Control Method*, the following is the default input constraint that applies:

Reverse *Input Range Min* <= Reverse *Input Range Max* <= Forward *Input Range Min* <= Forward *Input Range Max*

However, this constraint can be reversed if the following input adjustment occurs such that:

Forward *Input Range Max* <= Reverse *Input Range Max* <= *Input Max*

If the above occurs, then the constraint becomes:

Forward *Input Range Min* <= Forward *Input Range Max* <= Reverse *Input Range Min* <= Reverse *Input Range Max*

With this control method, the inching behaviour of a selected gear is similar to that described in the *Forward Only, with Inching* section. As before, for either gear *Input At Ihold* and *Input At Iinch* both have to fall within the corresponding range defined by the *Input Range Min* and *Input Range Max*parameters, but are otherwise not related to one another. The graphs below show how the inching response for the REVERSE gear is a negative slope, while that of the FORWARD gear has a positive slope. Alternately, this

could be setup for the opposite slope responses, or even that both gears use positive or negative slopes at the same time.

With either gear, if the input comes into the range defined by the corresponding *Input Range Min* and *Input Range Max* parameters, it will initially be turned on with a normal profile engagement. This means the current through the gear will jump to *Ifill* for the period *Tfill*, then drop immediately to *Ihold* for the period *Ihold*. If the input is in the "inching" range, it will then ramp to the current level required by the inching profile at the *Ramp* rate. If the input goes outside of the inching range, but is still within the gear's range, the output will *Ramp* from whatever current it was at while inching to *Imax*.

In the example below, the REVERSE gear would be fully engaged only in the region defined by Reverse *Input Range Min* to *Input At Iinch.* Since in this example *Input At Ihold = Input Range Max* the output current would be inversely proportional to the input while it is in the range *Input At Iinch* to *Input At Ihold.* Recall, as soon at the input goes above *Input Range Max* the output drops to zero and the unit in this example would go to NEUTRAL gear.

As the controller is in NEUTRAL gear (both gears, FORWARD and REVERSE, are inactive), the outputs will remain driven at the current specified in *Inactive Gear Current* parameter. This is also true for the output which is inactive. For example, if the controller is in FORWARD gear, the REVERSE gear (output) is driven at the *Inactive Gear Current*. If *Inactive Gear Current* is set to 0mA, then the outputs will be OFF.

As the input increases, the FORWARD gear would be turned ON with the normal engagement profile. Since in this case *Input At Ihold = Input Range Min*, the gear would engage in the inching mode, where the output current would be directly proportional to the input while it is in the range *Input At Ihold* to *Input At Iinch.* When the input is within the range defined by *Input At Iinch* to *Input Range Max* the FORWARD gear would be fully engaged.

To prevent oscillation at the points on the response profile when the output jumps from one level to another, there is hysteresis built in at each point. The amount of hysteresis is defined in the table in the *Input Type* section, and is fixed based on the type selected.

Also, as described in the *Forward Only, with Inching* section, if for negative inching responses *Input At Ihold* does not equal *Input Range Max,* or for positive slopes *Input At Ihold* does not equal *Input Range Min*, there is logical hysteresis as well. In the inverse response, as the input is increasing, the output will stay at *Ihold* when *Input At Ihold* <= InMeasured <= *Input Range Max.* However, if the gear was in NEUTRAL and the input drops into the range defined by [*Input At Ihold, Input Range Max*] the output will be fully turned on to *Imax* using the normal engagement profile and would only ramp down to the *Ihold* value when the input drops below the *Input At Ihold* threshold.

The same logic applies for the positive inching response, but in this case it relates to the region defined by *Input Range Min* <= InMeasured <= *Input At Ihold*. Here, when the

gear was in NEUTRAL and the input goes into the range defined by [*Input Range Min, Input At Ihold*] the output will be fully turned on to *Imax* using the normal engagement profile and would only ramp down to the *Ihold* value when the input goes above the *Input At Ihold* threshold. However, if the output was already in the inching range and the input drops below the *Input At Ihold* limit, the output will stay at the *Ihold* current.
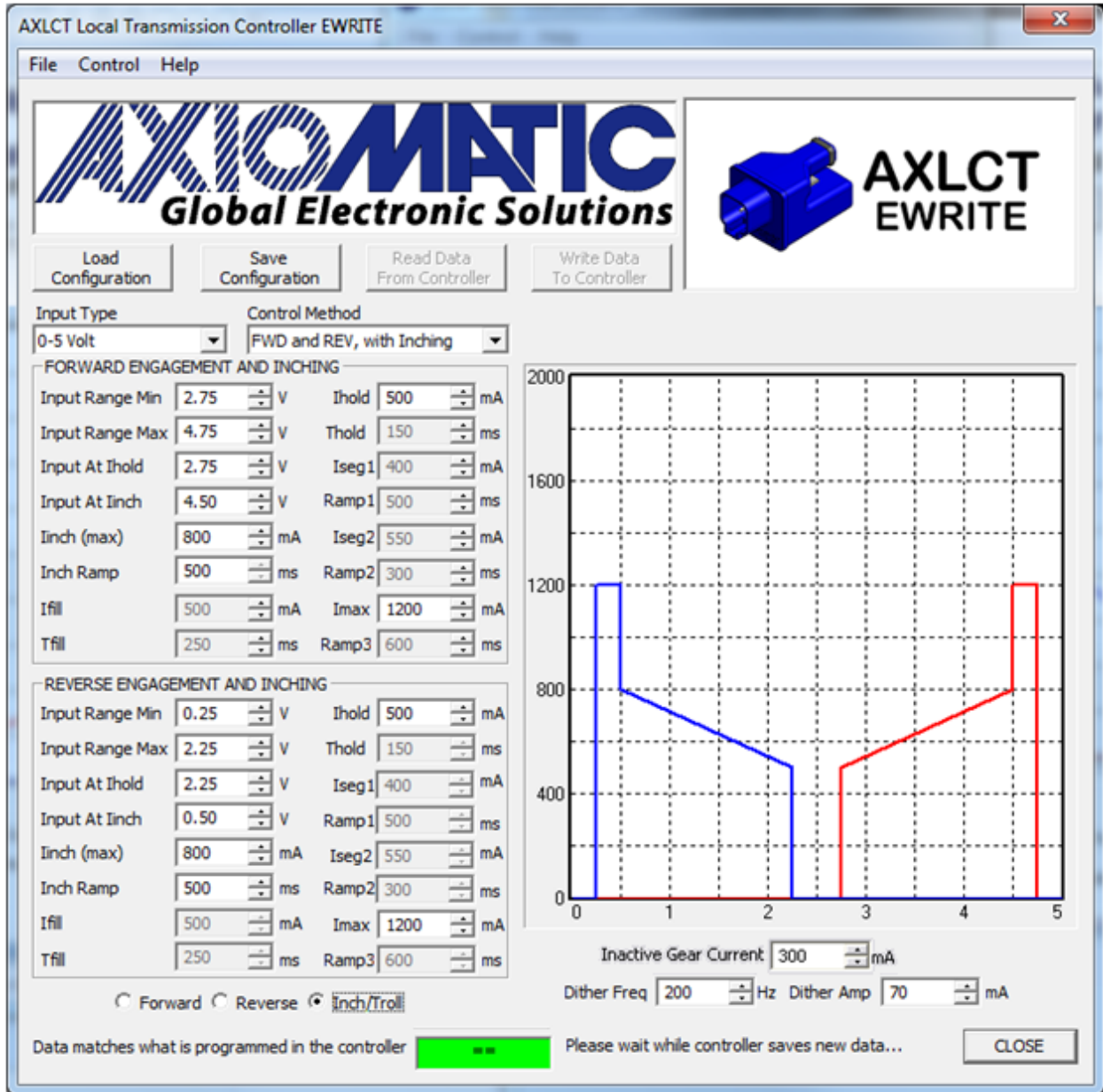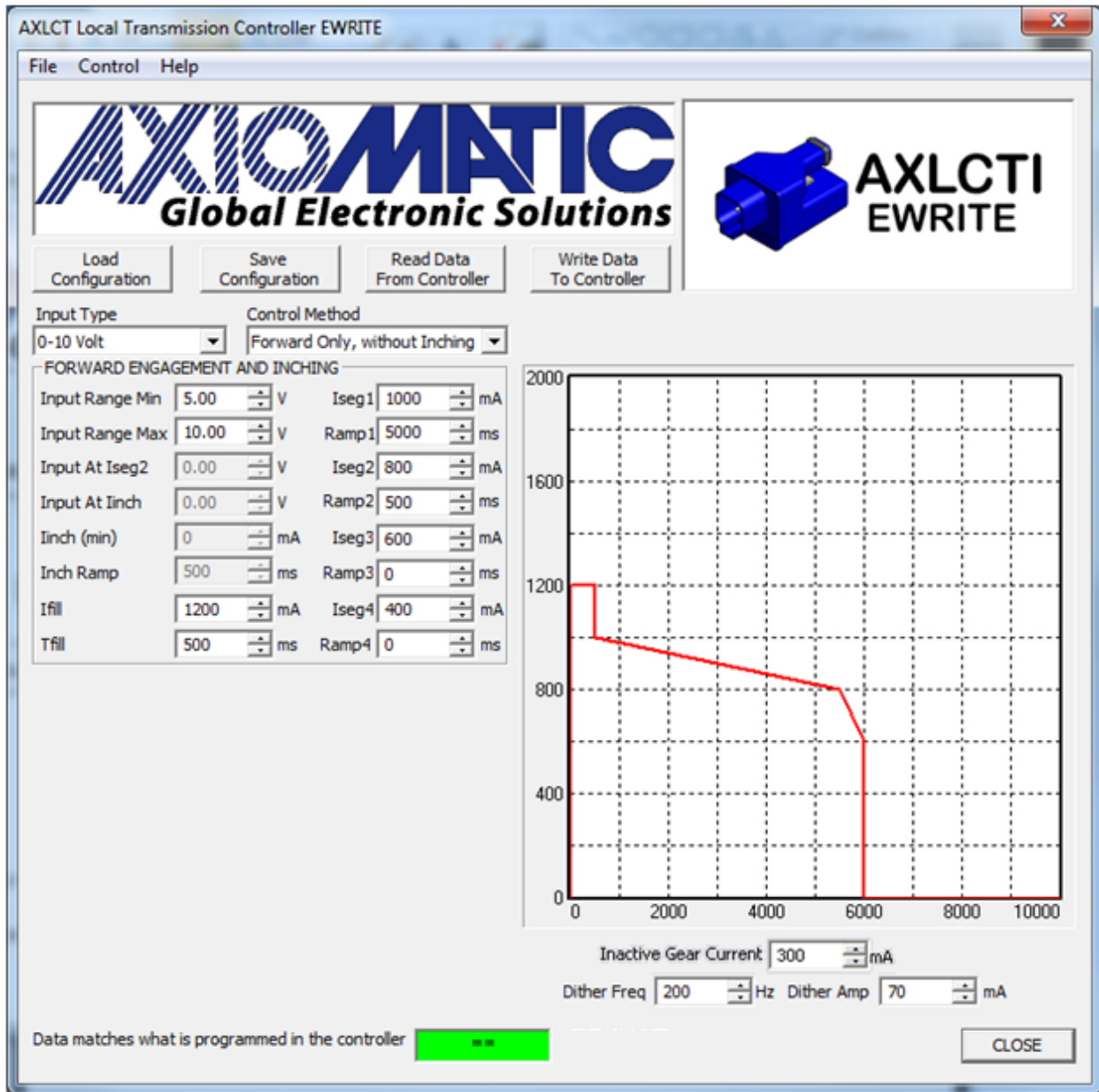
6. AXLCTI Local Inverse Transmission Controller Help

6.1. PINOUT

1	Reverse -
2	Signal -
3	Signal +
4	Power +
5	Power -
6	Reverse +

1	Forward +
2	Forward -
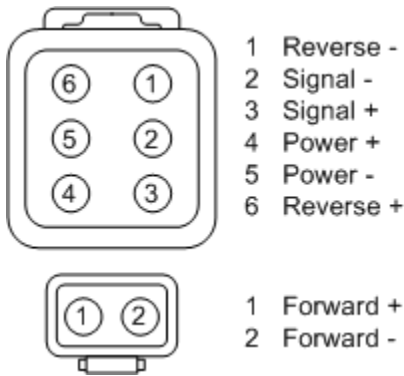
6.2. DEFAULTS

The screen capture below shows the default configuration of an AXLCTI Inverse Transmission controller as received from the factory. In the case of the AXLCTI Inverse type, the VIRTUAL UNIT defaults match those of the factory defaults.

6.2.1. Forward Screen

By default, the AXLCTI Inverse unit is setup to only drive a Forward coil. As with the regular AXLCT Local Transmission Controller, if the input measures below or above the range for a particular output (FORWARD or REVERSE), the output will be OFF. If the input is not within either output's valid ranges, both outputs will be off, and the unit will be in NEUTRAL. The difference between this unit and the regular AXLCT is that when the output is engaged, it will start with a normal *Ifill* for *Tfill* time, but then instead of dropping to a holding current before ramping UP to Imax, it will ramp DOWN to the *Iinch (min)* value, which is set to 0mA by default. As shown in the example below, the output will ramp with up to two different slopes until the minimum current value is reached.

AXLCT Local Transmission Controller EWRITE

File   Control   Help

AXIOMATIC
Global Electronic Solutions

AXLCTI
EWRITE

| Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller |

Input Type
0-10 Volt

Control Method
Forward Only, without Inching

FORWARD ENGAGEMENT AND INCHING

Input Range Min   5.00   V   Iseg1   1000   mA
Input Range Max   10.00   V   Ramp1   5000   ms
Input At Iseg2   0.00   V   Iseg2   800   mA
Input At Iinch   0.00   V   Ramp2   500   ms
Iinch (min)   0   mA   Iseg3   600   mA
Inch Ramp   500   ms   Ramp3   0   ms
Ifill   1200   mA   Iseg4   400   mA
Tfill   500   ms   Ramp4   0   ms

Inactive Gear Current   300   mA
Dither Freq   200   Hz   Dither Amp   70   mA

Data matches what is programmed in the controller

CLOSE

The AXLCT Transmission and AXLCTI Inverse are very similar in function, so please refer to the AXLCT Help tab for more information.

6.3.   CHANGES IN INCHING RESPONSE

The only other difference in behaviour is related to the inching response as described below. As can be seen in the example, a particular gear's output will be either directly or inversely proportional to the input while it is within the range defined by the [*Input at IsegB*, *Input At Iinch*] parameters. When it is outside this range, but still within the gear's range defined by [*Input Range Min, Input Range Max*] the output will stay at the *Iinch (min)* current level. As with the regular AXLCT, when the unit first goes from NEUTRAL to either FORWARD or REVERSE, the full engagement profile is always applied until the current required by the inching input is reached.

AXLCT Local Transmission Controller EWRITE

File   Control   Help

AXIOMATIC
Global Electronic Solutions

AXLCTI
EWRITE

| Load Configuration | Save Configuration | Read Data From Controller | Write Data To Controller |

Input Type
0-5 Volt

Control Method
FWD and REV, with Inching

FORWARD ENGAGEMENT AND INCHING
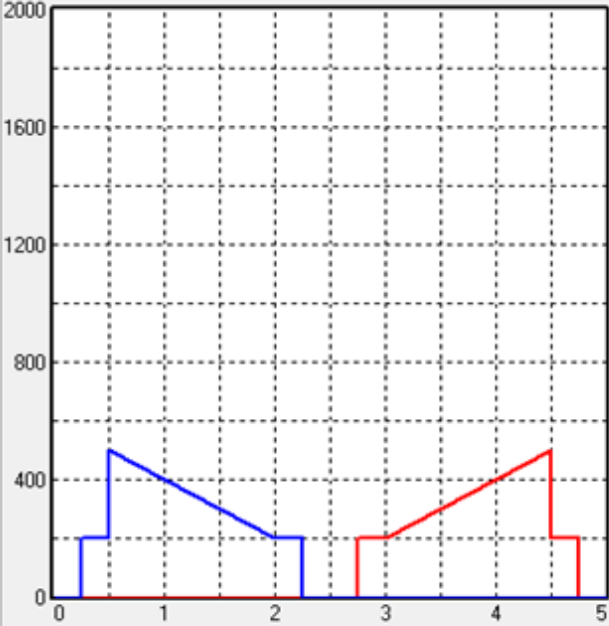
Input Range Min	2.75	V	Iseg1	1000	mA
Input Range Max	4.75	V	Ramp1	5000	ms
Input At Iseg2	4.50	V	Iseg2	800	mA
Input At Iinch	3.00	V	Ramp2	500	ms
Iinch (min)	200	mA	Iseg3	600	mA
Inch Ramp	500	ms	Ramp3	0	ms
Ifill	1200	mA	Iseg4	500	mA
Tfill	500	ms	Ramp4	0	ms

REVERSE ENGAGEMENT AND INCHING

Input Range Min	0.25	V	Iseg1	1000	mA
Input Range Max	2.25	V	Ramp1	5000	ms
Input At Iseg2	0.50	V	Iseg2	800	mA
Input At Iinch	2.00	V	Ramp2	500	ms
Iinch (min)	200	mA	Iseg3	600	mA
Inch Ramp	500	ms	Ramp3	750	ms
Ifill	1200	mA	Iseg4	500	mA
Tfill	500	ms	Ramp4	250	ms

○ Forward   ○ Reverse   ⦿ Inch/Troll

Data matches what is programmed in the controller

Inactive Gear Current 300 mA

Dither Freq 200 Hz   Dither Amp 70 mA

CLOSE

APPENDIX A - Technical Specifications

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process as described on https://www.axiomatic.com/service/.

Power Supply Input

Power Supply Input - Nominal	12Vdc, 24Vdc nominal (8…36 Vdc power supply range)
Protection	Reverse polarity protection is provided. Transient and surge protection is provided. Under-voltage protection at 6Vdc is provided. Overvoltage protection up to 40Vdc is provided.

Inputs

Command Signal Input	1 universal signal input is provided. See below. All input modes are user selectable.
Analog Input Functions	Voltage [V], Current [mA], Resistive [kΩ], PWM [%], Frequency [Hz], Digital
Voltage Input	0-5V 0-10V
Current Input	0-20mA (Impedance 249 Ω) 4-20mA (Impedance 249 Ω)
Resistive Input	10Ω to 5 kΩ
PWM Input	100 Hz to 10 kHz PWM Range 0 to 100% D.C. 1.5V to 3.5V
Digital Input	Active High up to +Vsupply or Active Low to Ground Amplitude: 0V to +Vsupply
Input Resolution and Accuracy	12-bit Analog to Digital (voltage, current, resistive) Voltage Type: 1 mV resolution, +/- 1% accuracy Current Type: 1 µA resolution, +/- 1% accuracy Resistive Type: +/-1 % accuracy PWM Type: 100 Hz to 10 kHz signal: +/- 0.5% accuracy
Protection	The inputs are protected against shorts to GND or +V$_{PS}$.

Outputs

Output Functions	Two outputs are configurable as follows. Proportional Current [mA] or On/Off
Output Type	High side switch (sourcing output) 0 – 3.5A (hardware) NB. Software allows up to 3A. Half-bridge output, current sensing, grounded load High frequency drive
Output Resolution and Accuracy	Output Current mode: 1mA resolution, +/- 2% full scale error Output Voltage mode: 0.1V resolution, accuracy +/-5% error Output PWM mode: 0.1% resolution, accuracy +/-0.1% error
Digital Output	If digital output is selected, it is sourcing from power supply or output off. The load at supply voltage must not draw more than 3.5A.
Dither	50 to 400 Hz 0 to 10% of I-max.
Ramp Times	Independent 0-60 seconds Full scale (0 mA to maximum current)
Protection for Output A+	Output A which plugs directly into the valve is protected against a short to GND.
Protection for Output B+	Output B is protected against short circuit to ground and short circuit to power supply rail. Unit will fail safe in the case of a short circuit condition, self-recovering when the short is removed.
Output GND Reference	Two output grounds are provided.

General Specifications

Quiescent Current	40 mA @ 12VDC; 24 mA @ 24VDC
Microprocessor	STM32, 32-bit, 128 Kbyte program memory
Control Logic	User programmable functionality using a service tool. The controller includes user selectable standard control profiles identified by model type: AXLCV Valve Controller; AXLCF Fan Controller; AXLCT Transmission Controller; or AXLCTI Transmission Controller with inverse profile. The controller includes user selectable control profiles for single output/single slope, single output/dual slope, dual output/single slope or dual output/dual slope. Parameters to fine tune the outputs to the fan, include: cold start; hotshot; coldshot; auto over temperature; and other configurable settings. There is an inching control method configurable as on or off and assigned to forward or reverse operation. Refer to the User Manual for details.
User Interface	A service tool is available for user configuration, the Axiomatic Local Controller EWRITE. The service tool is available from www.axiomatic.com. Go to the Log-In tab. Contact sales@axiomatic.com for the password. The Axiomatic Local Controller EWRITE service tool, requires a configuration cable, P/N: AX070127. The configuration cable allows access to the one-wire serial port (over the universal input pin).
Enclosure	Molded Enclosure, integral connectors, Ultrasonic welded assembly Polyester, 15% glass Silicone seals 3.037 x 1.44 x 1.660 inches (77.1 x 36.6 x 42.2 mm) L x W x H including integral connectors
Protection	IP67 rating for the product assembly
Weight	0.15 lb. (0.068 kg)
Temperature Rating	Operating: -40 to 85°C (-40 to 185°F) Storage: -50 to 105°C (-58 to 221°F)
Connectors	6-pin Integral Connector (equivalent TE Deutsch P/N: DT04-6P) which mates to TE Deutsch P/N; DT06-6S (not supplied) 2-pin Integral Connector (equivalent TE Deutsch P/N: DT06-2S) - mates to valve coil with integral DT04-2P Connector (not supplied)
Electrical Pinout	Wires should be of the appropriate gauge to meet requirements of applicable electrical codes and suit the specifications of the connector(s).

6-pin Connector

Pin #	Description	AXLCV Valve Controller	AXLCF Fan Controller	AXLCT Transmission Controller	AXLCTI Inverse Transmission Controller
1	Solenoid B-	Solenoid B-	REV-	REV-	REV-
2	Signal -	Signal -	Signal -	Signal-	Signal-
3	Signal +	Signal +	Signal +	Signal+	Signal+
4	Power +	Power +	Power +	Power+	Power+
5	Power -	Power -	Power -	Power-	Power-
6	Solenoid B+	Solenoid B+	REV +	REV+	REV+

2- pin Connector

Pin #	Description	AXLCV Valve Controller	AXLCF Fan Controller	AXLCT Transmission Controller	AXLCTI Inverse Transmission Controller
1	Solenoid A+	Solenoid A+	FAN +	FWD+	FWD+
2	Solenoid A-	Solenoid A-	FAN -	FWD-	FWD-

2.287 in
[58.1 mm]

1.528 in
[38.8 mm]

.590 in
[15.0 mm]

pin 6   pin 1

1.575 in
[40.0 mm]

1.660 in
[42.2 mm]

2.912 in
[74.0 mm]

.728 in
[18.5 mm]

3.037 in
[77.1 mm]

A

pin 2

pin 1

detail A
Molded in Deutsch IPD
p/n DT04-2S, mates to valve
coil with integral DT04-2P connector
(not supplied).

P/N: AX022320

3 4   1 REV -
       2 Signal -
       3 Signal +
       4 Power +
1 6   5 Power -
       6 REV +

       1 FWD +
2 1   2 FWD -

label detail

molded in Deutsch IPD
p/n DT04-6P, mates to Deutsch IPD
p/n DT06-6S, sold as part of
mating plug kit PN AX070119

7. Version History

Version	Compatible Tool Version	Date	Author	Modifications
1	V1.x.x	August 20th, 2015	Gustavo Del Valle	Initial Draft
2	V2.x.x	December 21st, 2015	Gustavo Del Valle	Added setpoint *Inactive Gear Current* for AXLCT and AXLCTI versions
3	3.x.x	May 3rd, 2016	Gustavo Del Valle	Added functionality to reverse operation of AXLCT gears by enabling reverse limits on command signal
3	3,xx	May 27th, 2016	Amanda Wilkins	Added technical spec to Appendix.
3A	3.xx	August 26th, 2016	Gustavo Del Valle	Updated the Technical Specification section (Appendix A) to correct the PWM input allowable frequency range
4	4.x.x	January 9th, 2018	Gustavo Del Valle	Added the following to AXLCV: • New Control Method: *Double Independent* • Added ability to change output types • Added setpoint to change output frequency Increased the maximum output current range from 2000mA to 3000mA
-	-	October 30, 2019	Amanda Wilkins	Updated reference to cable in intro to AX070127. Updated footer to new Axio Oy address.
5	5.x.x	November 29, 2021	Amanda Wilkins	Added ramp up to 60 seconds.
5.1	-	August 9, 2023	Kiril Mojsov	Performed Legacy Updates

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Fan Drive Controllers

Gateways, CAN/Modbus, RS-232

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Inclinometers, Triaxial

I/O Controls

LVDT Signal Converters

Machine Controls

Modbus, RS-422, RS-485 Controls

Motor Controls, Inverters

Power Supplies, DC/DC, AC/DC

PWM Signal Converters/Isolators

Resolver Signal Conditioners

Service Tools

Signal Conditioners, Converters

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

Axiomatic provides electronic machine control components to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets. *We innovate with engineered and off-the-shelf machine controls that add value for our customers.*

QUALITY DESIGN AND MANUFACTURING
We have an ISO9001:2015 registered design/manufacturing facility in Canada.

WARRANTY, APPLICATION APPROVALS/LIMITATIONS
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COMPLIANCE
Product compliance details can be found in the product literature and/or on axiomatic.com. Any inquiries should be sent to sales@axiomatic.com.

SAFE USE
All products should be serviced by Axiomatic. Do not open the product and perform the service yourself.

 This product can expose you to chemicals which are known in the State of California, USA to cause cancer and reproductive harm. For more information go to www.P65Warnings.ca.gov.

SERVICE
All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#) from sales@axiomatic.com. Please provide the following information when requesting an RMA number:
- Serial number, part number
- Runtime hours, description of problem
- Wiring set up diagram, application and other comments as needed

DISPOSAL
Axiomatic products are electronic waste. Please follow your local environmental waste and recycling laws, regulations and policies for safe disposal or recycling of electronic waste.

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