Module Overview

The 3601 module is a one-axis stepper controller that occupies one slot in either a MicroLogix 1500 or a CompactLogix system. This unit receives profile data from the PLC and outputs Step and Direction signals or Clockwise/Counter Clockwise pulses to a stepper driver. Inputs on the module allow homing, emergency stop, registration, and capture operations. A differential incremental encoder can be attached to the unit to provide feedback information.

The 3601 module uses 8 input and 8 output registers to communicate with the PLC. The Current Position, Encoder Count Value, and a Capture Value are reported to the Input Registers. The 8 output registers have two purposes. First, they are used to configure the module with parameters such as Output Type, Homing Type, Inputs Used, Input Active Level, and Starting Speed. Second, they are used to send the move commands, along with the distance, speed, and acceleration and deceleration rates used to define the move profile.

32-bit parameters are divided into two words, the MSW and LSW. The upper word (MSW) has the 1000s places and the lower word (LSW) has the 1s, 10s and 100s places. Negative values are handled by setting both the upper and lower words independently negative. For example:

Value	MSW	LSW
-12,345	-12	-345
12,000	12	0
-12,000	-12	0
345	0	345
-345	0	-345

Because the 3601 module does not use a non-volatile memory, it must be configured at every power up.

Sample programs showing how to program the 3601 module in both MicroLogix 1500 and CompactLogix systems are available from the following page of our website.

http://www.amci.com/sampleprograms.asp

General Information

Important User Information

The products and application data described in this manual are useful in a wide variety of different applications. Therefore, the user and others responsible for applying these products described herein are responsible for determining the acceptability for each application. While efforts have been made to provide accurate information within this manual, AMCI assumes no responsibility for the application or the completeness of the information contained herein. Throughout this manual the following two notices are used to highlight important points.

WARNINGS tell you when people may be hurt or equipment may be damaged if the procedure is not followed properly.

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Returns Policy

All equipment being returned to AMCI for repair or replacement, regardless of warranty status, must have a Return Merchandise Authorization number issued by AMCI. Call (860) 585-1254 with the model and serial numbers along with a description of the problem. A "RMA" number will be issued. Equipment must be shipped to AMCI with transportation charges prepaid. Title and risk of loss or damage remains with the customer until shipment is received by AMCI.

24 Hour Technical Support Number

Technical Support, in the form of documents, FAQs, and sample programs, is available from our website, www.amci.com. 24 Hour technical support is also available on this product. For technical support, call (860) 583-7271. Your call will be answered by the factory during regular business hours, Monday through Friday, 8AM - 5PM EST. During non-business hours, an automated system will ask you to leave a detailed message and the telephone number where you can be reached. The system will page an engineer on call. Please have your product model number and a description of the problem ready before you call.

3601 Module Manual
MicroLogix 1500 & CompactLogix Stepper Module

Table of Contents

Chapter 1: Installing the 3601 module

WARNING Disconnect power before attempting to install or remove the 3601 module.

1. Verify that your system's power supply has adequate reserve current capacity. The 3601 module requires 400mA at +5Vdc.
2. The 3601 cannot be any farther than the 7th module away from the power supply.
3. Align the tongue-and-groove guides on the left side of the module with the existing rack system and slide the module backwards.
4. When the 3601 module is in position, move the white bus connector lever on the top of the module to the left.
5. If the 3601 module is the right most module in a system, a 1769-ECR End Cap MUST be installed to the right of the module for the system to operate correctly.

CompactLogix Generic Configuration

1. Open RSLogix 5000 and the project in which you want to install the AMCI 3601 module.
2. Right click on I/O Configuration in the Project Tree.
3. Select New Module.
4. Select the following module type and description from the list that appears.

   Type = 1769-MODULE
   Description = Generic 1769 Module

5. Click on OK.
6. Enter the following module properties.

   Name: *Your Choice* (must begin with a letter)
   Description: *Your Choice*
   Comm Format: *Data-INT (*The default is *Input Data-INT.* This <u>must be changed</u> to *Data-INT)*
   Slot: *location of 3601 module*

7. Enter the Connection Parameters from the following table.

CONNECTION PARAMETERS

	Assembly Instance	Size in 16 bit words
INPUT	101	8
OUTPUT	100	8
CONFIGURATION	102	0

8. Click on Finish >>

The 3601 module will now appear in the project tree and three new data tags will have been created, Local:X.I.Data[Y], Local:X.O.Data[Y] and Local:X.C.Data[Y] where "X" is the slot number and "Y" is the word number. The status, current position, encoder position, and captured data value are located in the Input tags. All commands are sent to the 3601 module through the Output tags. The 3601 module does not use the Configuration tags.

CompactLogix RSLogix 5000 V20 or higher configuration

With the release of V20 of RSLogix 5000, the AMCI 3601 module is now present in the list of available CompactLogix I/O modules, so you now have the option of using either this or the Generic module described above when adding the AMCI 3601 module to your I/O.

1. Open RSLogix 5000 and the project in which you want to install the AMCI 3601 module.
2. Right click on I/O Configuration in the Project Tree.
3. Select New Module.
4. Verify that the **By Vendor** tab is selected at the bottom of the Select Module window and expand Advanced Micro Controls. The following window will open.

5. Double click on the 3601 module. The following window will appear.
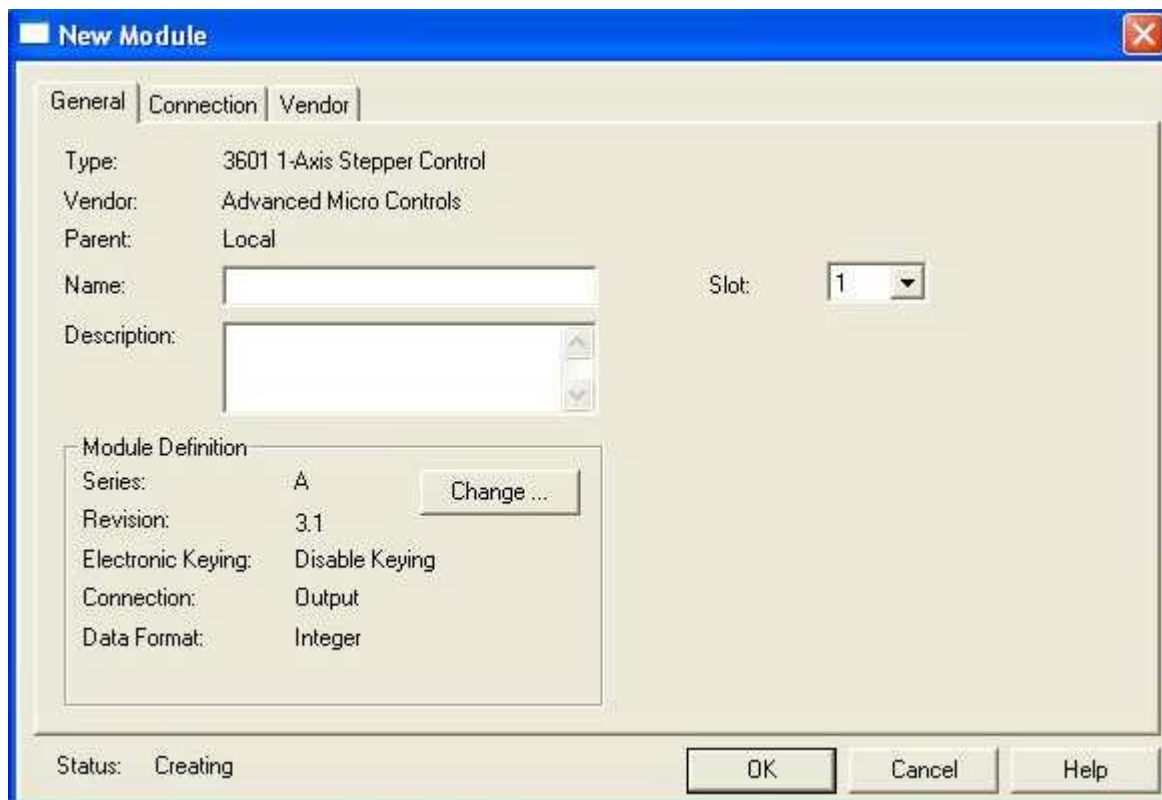
6. Enter a name in the Name field. This parameter must begin with a letter.
7. If desired, describe the function of the 3601 module in the *Description* field.
8. Click on the ▼ next to the *Slot* field and select the slot where the AMCI 3601 module is to be located.
9. Click on OK to add the 3601 module to your I/O configuration.
10. Using the above setup changes how the data from the 3601 module will be read into the Controller tags. Instead of the generic Local:X:I.Data and Local:X:O.Data tags, the module will now use tags that are specific for the 3601 module.

MicroLogix 1500 Configuration

Note: Only 3601 modules with version 2.2 or higher firmware, serial number 78769 or greater, will operate in a MicroLogix system. The firmware version number is reported in the input data while the 3601 module is in Configuration Mode. Older units must be returned to AMCI to be upgraded.

1. Open or create the RSLogix 500 project in which you want to use the 3601 module.
2. Double click on I/O Configuration in the project tree.
3. Select the slot where the 3601 module will be installed.
4. Double click on "Other. Requires I/O Card Type ID" from the bottom of the list of available modules.
5. Enter the following information in the window that appears.

Vendor ID:	3
Product Type:	10
Product Code:	25
Series/Major Rev/Minor Rev:	A
Input Words:	8
Output Words:	8
Input Bits:	0
Output Bits:	0
Extra Data Length:	0
Ignore Configuration Error:	*Your Choice, but not recommended*

6. The 3601 module will now appear in the I/O Configuration with a Part Number of Other and a Description of I/O Module – ID Code = 25.
7. Input Data (data from the 3601 module to the PLC) will appear in Input Image Table registers I:X.0 to I:X.7, where X is the slot number.
Output Data (data from the PLC to the 3601 module) will be written to registers O:X.0 to O:X.7, where X is the slot number.

Module Specifications

- Backplane Current Draw: 400mA @5Vdc
- Throughput Time: 250 μs
  (Inputs must be on for 250 μs to be scanned by the module)
- CompactLogix RPI time: fixed at 2ms

Stepper Outputs

Output Voltage: +5Vdc differential (3.5Vdc to 4Vdc peak typical)
Maximum Output Current: 20mA
Maximum Output Frequency: 1MHz

Encoder Inputs

5V differential encoder only
A, B, and Z Maximum Input Current: 10mA per channel @5Vdc
A, B, and Z Maximum Input Frequency with X4 decoding = 1MHz

The A and B signals must both be connected to the 3601 module to have the encoder data increment or decrement.

Because X4 decoding is used, the maximum frequency of the A and B signals is 250kHz.

When used for Diagnostic Feedback, the encoder inputs have a maximum input frequency of 500kHz.

Discrete Inputs

Input Type: Sinking
Input Voltage Range: On = 8 to 24Vdc
                         Off = 0 to 2Vdc

Input Current: 15mA @ 24Vdc
Response Time   (On and Off): 5μs
Scanning Time: The input must be on for 250ms to be detected by the module.
Active State: The discrete inputs can be configured to be Active High (for use with a normally open contact) or Active Low (for use with a normally closed contact).
Input Functions: Capture Input, External Input, Home Input, Emergency Stop, CW Limit Switch, and CCW Limit Switch. (The External Input only affects Absolute, Relative, and Manual Moves. The Home input only affects Homing operations.)

Environmental Conditions
Operating Temperature: 0 to 60° C
Relative Humidity: 5 to 95%   (non-condensing)
Storage Temperature: -40 to 85° C

Front Panel

MODULE	🟩
AXIS OK	🟩
AXIS ERR	🟥
STEPPER	

Out · Out · O · In · O
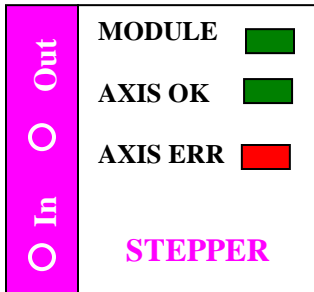
Module LED
<u>Solid Green</u>: Module Owned, two-way communication

Axis OK and Axis Error LED
<u>Alternating Blinking Green & Red</u>: Module failed power up diagnostics
<u>Blinking Together Green & Red:</u> Communication lost between the 3601's CPU and the backplane ASIC.

Axis OK LED
<u>Solid Green</u>: Module OK, no motion in progress
<u>Blinking Green</u>: Module OK, motion occurring or Encoder Follower Mode is enabled
<u>Off</u>: Not Configured or any of errors indicated by a blinking red Axis Err LED.

Axis Err LED
<u>Solid Red</u>: Communication between module and PLC interrupted
<u>Blinking Red</u>: Configuration Error, Command Error, Input Error, Home Invalid Error, or an Invalid Profile Error.

Output Signals

The 3601 module can be programmed to output either Step and Direction signals or CW / CCW steps. There is no advantage to either type; you must simply configure the 3601 module to match the input type of your driver. The two types of signals are illustrated below.

Step and Direction Output

Step Output

Direction Output

CCW Motion or Decreasing Counts

CW Motion or Increasing Counts

CW and CCW Step Outputs

CW Output

Increasing Counts

Decreasing Counts

CCW Output
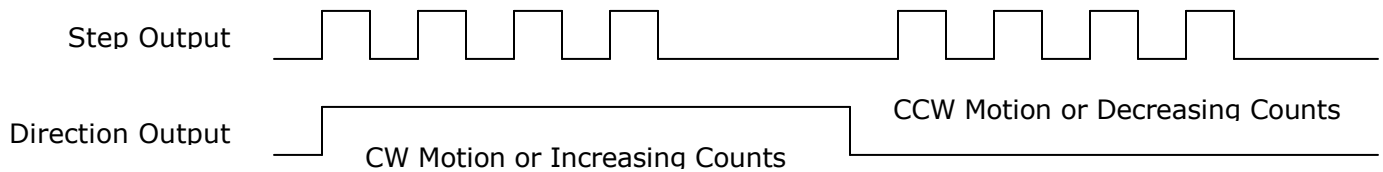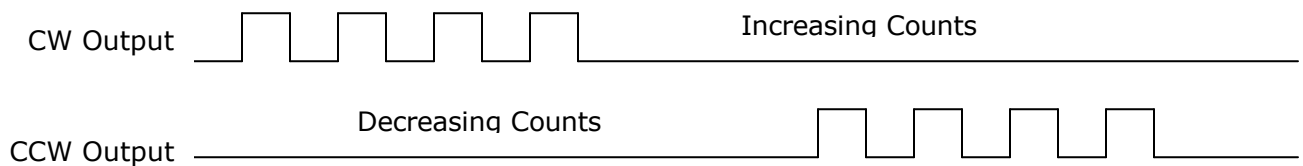
Connector Pin Out

The input connector is included with the 3601 module and consists of an eighteen position Removable Terminal Block. The following diagram shows the wiring of this Terminal Block.

Note: Pin 1 is located on the upper left when the Terminal Block is plugged into the unit.

| Left label	Pin		Pin	Right label
+A Encoder Input	1		2	-A Encoder Input
+B Encoder Input	3		4	-B Encoder Input
+Z Encoder Input	5		6	-Z Encoder Input
-Step or -CW output	7		8	+Step or +CW output
-Direction or -CCW output	9		10	+Direction or +CCW output
CW Limit Switch	11		12	Emergency Stop Input
Capture Input	13		14	CCW Limit Switch
External Input	15		16	Home Input
Module Common	17		18	Chassis Ground (shields)

Wiring Notes:

- The 3601 module uses a 9638 differential line driver in series with a 10Ω resistor for the stepper (+/- step and +/- direction) outputs.
- Stepper signals are generally low voltage, low power signals. If you are using A-B guidelines for cabling installation, treat the cable as a Category 2 cable. It can be installed in conduit along with other low power cabling such as communication cables and low power ac/dc I/O lines. It cannot be installed in conduit with ac power lines or high power ac/dc I/O lines.
- To reduce or eliminate the influence of electrical noise on the system, the step and direction cable shields must be connected to chassis ground terminal 18. Also, the shields must be connected to only one end of the cable run and treated as conductors at any junctions. Do not ground the shields at the junction box.
- If the signal cable must cross power feed lines, it should do so at right angles.
- Route the cable at least five feet from high voltage enclosures, or sources of "rf" radiation.
- The Module Common (pin 17) <u>must</u> be connected to the COM of the supply that powers the discrete inputs. A Stepper Driver with Single Ended Step and Direction inputs can also be referenced here.
- The Chassis Ground pin is connected to the PLC's chassis ground.

Discrete Inputs Wiring

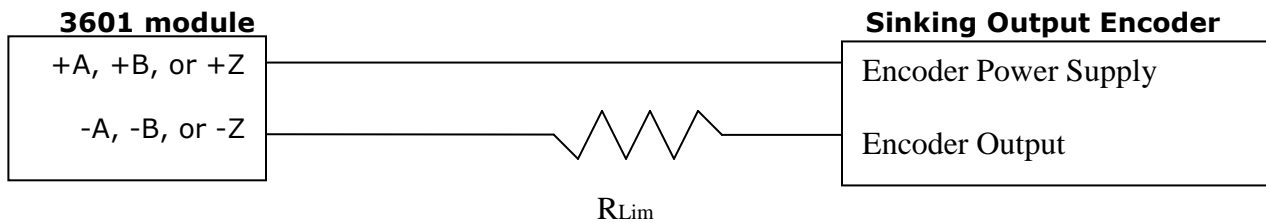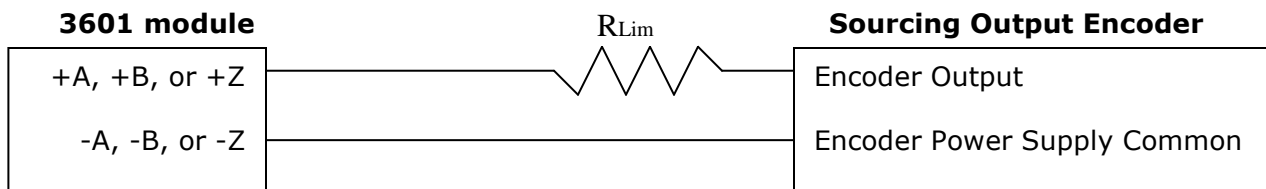The following diagram shows how to wire the 3601 module's discrete sinking inputs to a sourcing sensor.

3601 Module	Discrete Input (pins 11, 12, 13, 14, 15 or 16) Module Common (pin 17)	Sourcing Sensor	Power Supply + 8 to 24Vdc Common
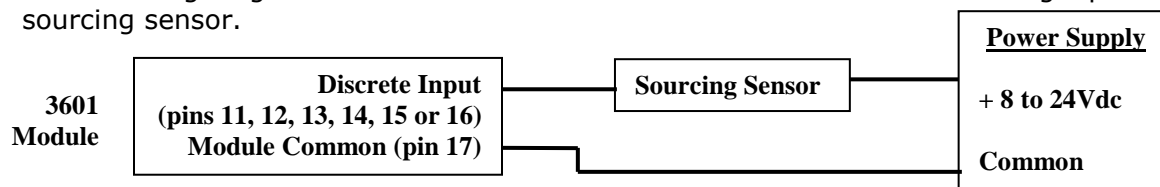
Single Ended Encoder Wiring

The 3601 module is designed to work with +5Vdc differential encoders. Use the following table and diagrams to attach single ended encoders to the 3601 module. A current limiting resistor RLim <u>must</u> be installed for encoders that do not operate at 5Vdc.

Encoder's External Power Supply	Current Limiting Resistor R_{Lim}
5Vdc	none
12Vdc	1KΩ
15Vdc	1.2KΩ
24Vdc	2.7KΩ

3601 module R_{Lim} **Sourcing Output Encoder**

+A, +B, or +Z ———/\/\/\——— Encoder Output

-A, -B, or -Z ——————————— Encoder Power Supply Common

3601 module   **Sinking Output Encoder**

+A, +B, or +Z ——————————— Encoder Power Supply

-A, -B, or -Z ———/\/\/\——— Encoder Output

R_{Lim}

Note: The single ended encoder wiring must be reversed on 3601 modules with serial numbers less than 96317. That is, the output of a sourcing encoder must be wired to the – Encoder Input of the 3601 module, and the output of a sinking encoder must be wired to the +Encoder Input of the 3601 module.

Diagnostic Feedback Wiring

| Pin Numbers	Signal Names
8 to 2	+Step to -A
7 to 1	-Step to +A
10 to 4	+Direction to -B
9 to 3	-Direction to +B

Note 1: The Diagnostic Feedback function will operate correctly with an input frequency up to 500kHz.

Note 2: The Diagnostic Feedback wiring will be different on units with rev A PC boards with serial numbers less than 96317. On these units, connect pin 8 to 1, pin 7 to 2, pin 10 to 3, and pin 9 to 4.

Chapter 2: Calculating Move Profiles

Before starting a move operation, the 3601 module completely calculates each portion of the move profile. That is, it calculates how many steps of the move profile will be required for acceleration and how many steps will be required for deceleration. Depending on the data used to define the move profile, this can result in two types of velocity profiles, either a *Trapezoidal Profile* or a *Triangular Profile.*

A *Trapezoidal Profile* jumps from rest to the Starting Speed, accelerates to the Programmed Velocity at the commanded acceleration rate, continues at the Programmed Velocity to a predetermined point, and then decelerates to the target position at the commanded deceleration rate to the starting speed and stops.

Trapezoidal Profile
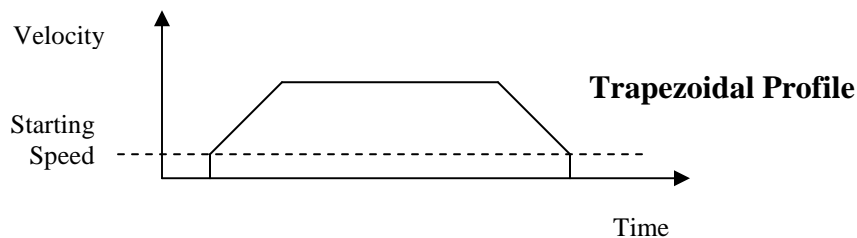
However, if the length of a commanded move is not long enough to attain the programmed velocity before the deceleration point is reached, a *Triangular Velocity* profile will be generated.

Triangular Profile
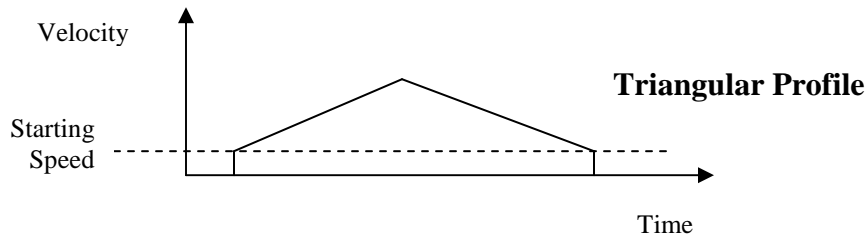
Regardless of the type of Velocity Profile that is being run, the following equations can be used to determine both the time to accelerate and the number of steps needed to accelerate. These formulas can also be used to calculate the time and distance to decelerate.

$$Ta = (Vs - Vo)/a$$
$$Da = Ta * (Vo + Vs)/2$$

Vo = Starting Speed (steps/second)
Vs = Programmed Speed (steps/second)
Ta = Time to accelerate (seconds)
Da = Distance to accelerate (steps)
a = Acceleration rate (steps/second/second)
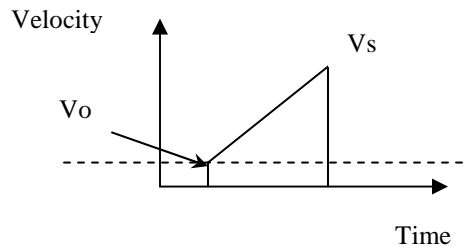
The acceleration rate entered in these equations <u>must</u> have units of steps/second/second, not the steps/ms/second used by the 3601 module. See the Calculation Notes below for a complete explanation.

For Triangular S Curve acceleration, Ta = 2 *Ta calculated by the above equations.
For Trapezoidal S Curve acceleration, Ta = 4/3 * Ta calculated by the above equations.

Calculation Notes

1. The acceleration and deceleration values sent to the 3601 module as part of the move profile have units of steps/ms/sec.

   If you are using the above formulas to calculate Ta (the time to accelerate), multiply the acceleration value sent to the 3601 module by 1000 before using it in the formulas.

   If you are using the above formulas to calculate the acceleration rate from a desired Time to accelerate, divide the result of the calculation by 1000 before using it as the acceleration parameter sent to the 3601 module.

2. If the number of steps to accelerate plus the number of steps to decelerate is greater than the number of steps programmed in the target position registers, than the 3601 module will run a *Triangular Velocity Profile*.
3. If the number of steps to accelerate plus the number of steps to decelerate is less than the number of steps programmed in the target position, than the 3601 module will run a *Trapezoidal Velocity Profile*.
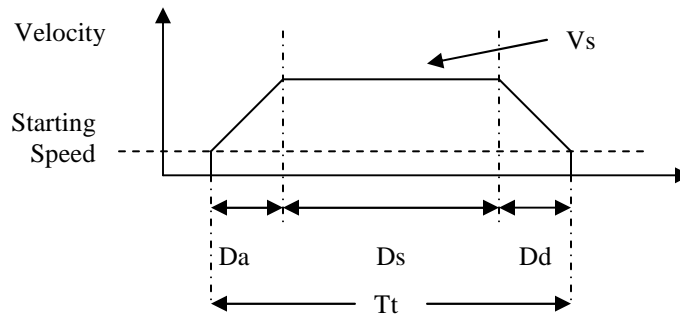
Ds = (Total Number of Steps) − (Da + Dd)
Tt = Ta + Td + Ds/Vs

Da = Distance to Accelerate (steps)
Ds = Distance at the programmed speed (steps)
Dd = Distance to decelerate (steps)
Vs = Programmed Speed (steps/sec)
Tt = Total Profile Time (seconds)

Starting Speed

The starting speed has a range of 1 to 1,000,000 pulses/sec and is the pulse frequency at which every move begins and ends. That is, the first and last pulses of the move profile will be at the starting speed.

Please note that configuring the 3601 module with a very low starting speed will increase the length of time between two consecutive moves.

Although it is not necessary, the smoothest transition from rest to the programmed speed will be achieved with a Starting Speed equal to the square root of the acceleration value.

Chapter 3: Configuration Programming

Configuration Mode

The Configuration Mode provides the ability to select the proper setup configuration to match the stepper application without having to set any switches. The configuration file, consisting of four 16-bit words, allows the following parameters to be defined.

1. If a CW Limit Switch will be used and its input active state
2. If a CCW Limit Switch will be used and its input active state
3. If an Emergency Stop will be used and its input active state.
4. If an External Input will be used and its active state.

   The external input can be used to stop a Manual Move operation, or to place an Absolute or Relative move in a hold state.

   If the External Input is active when a move operation is initiated, the 3601 module will generate one step in the specified direction and then stop.

5. If the Capture Input will be used and its active state.
6. If a Home Limit Switch will be used and its input active state.
7. If a Quadrature Encoder will be used with the system
8. If the channel will be configured for Diagnostic Feedback. Diagnostic Feedback allows the unit to count its own output pulses by wiring the outputs to the encoder inputs.
9. The output type, either CW and CCW Steps or Step and Direction.
10. The type of homing operation that will be performed. There are four Homing possibilities.

    1. Home Limit Switch Only
    2. Home Limit Switch with a backplane bit acting as a Home Proximity.
    3. Marker Pulse Home with the Home Limit Switch Input acting as a Home Proximity.
    4. Marker Pulse Home with a backplane bit acting as a Home Proximity.

    Note 1: When configured to use a Proximity Input, the 3601 module will ignore any other home inputs until the proximity input is detected.
    Note 2: The Backplane Proximity bit refers to a bit in the output register that must be be set before the 3601 module begins looking for the other home inputs.
    Note 3: The Marker Pulse option also requires the presence of the Quadrature Encoder.

11. The Starting Speed. The starting speed is the pulse frequency that every move begins and ends at. Some portions of the homing operations are also performed at the starting speed.

Configuration Mode Output Data
(Eight 16 bit words sent from the PLC to the 3601 module)

While in configuration mode, the output registers have the following format.

16 bit output Word	Configuration Output Data	Units	Range
0	Configuration Bits MSW		See description below
1	Configuration Bits LSW		See description below
2	Starting Speed MSW	Steps/Second	1 to 1,000,000
3	Starting Speed LSW		
4	0		
5	0		
6	0		
7	0		

The following table shows how the 3601's output registers will appear if the module was added to the CompactLogix I/O using the profile available in RSLogix 5000 V20 or above.

-Local:1:0	{...}	{...}		AM:1769_3601:0:0
+ Local:1:0.Data0	0		Decimal	INT
+ Local:1:0.Data1	0		Decimal	INT
+ Local:1:0.Data2	0		Decimal	INT
+ Local:1:0.Data3	0		Decimal	INT
+ Local:1:0.Data4	0		Decimal	INT
+ Local:1:0.Data5	0		Decimal	INT
+ Local:1:0.Data6	0		Decimal	INT
+ Local:1:0.Data7	0		Decimal	INT

Note 1: The module will power up in Command Mode showing a Configuration Error. The Configuration Error bit will remain set as long as valid configuration data has not been written to the module.

Note 2: If Configuration Mode is entered while a move is occurring, the Command Error bit will be set, the move will run to completion, and then the module will enter Configuration Mode.

Note 3: The Starting Speed is programmed in two words. The MSW contains the 1000 places and the LSW contains the 1s, 10s, and 100s places of the value. For example, if the starting speed is 12,345 steps/sec, than the MSW would 12 and the LSW would be 345.

Configuration Bits MSW

Bit 0: set when the Capture Input will be used. The Capture Input can be used in two ways.

1. Using the Capture Input <u>without</u> the Quadrature Encoder will capture the Current Position Data.
2. Using the Capture Input <u>with</u> the Quadrature Encoder will capture the Encoder Data.

Bit 1: set when an External Input is used.
Bit 2: set when a Home Limit Switch Input will be used.
Bit 3: set when the Emergency Stop Input will be used
Bit 4: set when a CW Limit Switch will be used
Bit 5: set when a CCW Limit Switch will be used
Bit 6: set for backplane Home Proximity operations

> The 3601 can be configured to ignore changes on the physical home input until the Command Mode Home Proximity Bit (Command Word LSW bit 12) makes a 0 to 1 transition. The 3601 will home on the next inactive to active change of the physical home input once this transition occurs. You must program your PLC to control the state of this bit. <u>Do not set this configuration bit if you want to home only to the home input.</u>

Bit 7: reserved for future use
Bit 8: set when Quadrature encoder will be used
Bit 9: set when diagnostic feedback will be used
Bit 10: "1" when output pulse type is pulse train and direction
      "0" when output pulse type is CW pulse train and CCW pulse train
Bit 11: reserved for future use
Bit 12: "0" for limit switch home operations, "1" for marker pulse home operations
Bits 13 and 14: reserved for future use
Bit 15: "1" for configuration mode operations, "0" for command mode operations

Configuration Bits LSW

Bit 0: determines the active level of the Capture Input
Bit 1: determines the active level of the External input
Bit 2: determines the active level of the Home Limit Switch input
Bit 3: determines the active level of the Emergency Stop input
Bit 4: determines the active level of the CW Limit Switch
Bit 5: determines the active level of the CCW Limit Switch
Bits 6 to 15: Reserved for future use

Input Active Level

Set these bits to define the input(s) to be active high (for use with a normally open contact) reset these bits to define the input(s) to be Active Low (for use with a normally closed contact). Please note that the active level of the inputs is taken into account only when the input has been defined as being used.

Set the bits of any inputs that are being configured but not used so that the Input Active Level is Active High.

Starting Speed

The starting speed has a range of 1 to 1,000,000 steps/sec and is the pulse frequency at which every move begins and ends. Some portions of the homing operations are also performed at the starting speed.

> **Note**: The Starting Speed can be any value less than or equal to the programmed speed of the slowest move. As a suggestion, a Starting Speed that is equal to the square root of the acceleration rate will create a profile without any jumps in the velocity at the beginning and end of the move profile.

Invalid Configurations

The 3601 module will not accept all possible configurations. The following is a list of the invalid configurations:

1. A configuration without the ability to home the module.
2. A configuration without at least one End Limit Switch, either CW or CCW.

    Note: The ability to home the module and at least one of the end limit switches have to be configured. They do not have to actually be used in the stepper application.

3. Using Quadrature Encoder and Diagnostic Feedback.
4. Using a Marker Pulse Home without the Quadrature Encoder.
5. Diagnostic Feedback with CW and CCW pulse outputs.
6. A starting speed outside the range of $1 \leq$ starting speed $\leq 1,000,000$.
7. If the lower word of the starting speed is outside of the range of 0 to 999.
8. Setting any of the unused bits in the configuration words.
9. Selecting Marker Pulse home without also selecting to use either the Home Input, which will act as a proximity limit, or the Backplane Proximity bit.
10. Selecting Marker Pulse home with both the Home Input and the Backplane Proximity bit.
11. Setting any of the unused words to a value other than zero.

The 3601 module has to be configured before starting any operations. When the Configuration Mode flag is set in the output registers, the stepper controller enters Configuration Mode. When in this mode, the stepper controller will finish its current operation and set the Configuration Mode flag in the input registers. It then waits for the configuration file to be transferred. If there is no current Configuration File present or if the transferred Configuration File is not valid, the Configuration Error Input bit will be set. If the transferred configuration file is accepted, the configuration data will be mirrored in the input registers.

Configuration Mode Input Data
(Eight 16 bit words sent from the 3601 module to the PLC)

While in configuration mode, the input registers will mirror the configuration data that was sent to the 3601 module in the output registers. The exceptions are the Module OK bit, input word 0, status bit 14 and the Configuration Error bit, input word 0, status bit 13.

16 bit Input Word	Configuration Input Data
0	Mirror of Configuration Bits MSW
1	Mirror of Configuration Bits LSW
2	Mirror of Starting Speed MSW
3	Mirror of Starting Speed LSW
4	0
5	0
6	Major Revision
7	Minor Revision

The following table shows how the 3601's input registers will appear if the module was added to the CompactLogix I/O using the profile available in RSLogix 5000 V20 or above.

⊟ Local:1:I	{...}	{...}		AM:1769_3601:I:0
⊞ Local:1:I.Fault	0		Decimal	DINT
⊞ Local:1:I.Data0	0		Decimal	INT
Local:1:I.ConfigError	0		Decimal	BOOL
Local:1:I.ModuleOK	0		Decimal	BOOL
Local:1:I.ConfigMode	0		Decimal	BOOL
⊞ Local:1:I.Data1	0		Decimal	INT
⊞ Local:1:I.Data2	0		Decimal	INT
⊞ Local:1:I.Data3	0		Decimal	INT
⊞ Local:1:I.Data4	0		Decimal	INT
⊞ Local:1:I.Data5	0		Decimal	INT
⊞ Local:1:I.Data6	0		Decimal	INT
⊞ Local:1:I.Data7	0		Decimal	INT

Note: Input Word 0, bits 13 to 15 are not mirrored. These three bits always function as status bits, regardless of whether the 3601 module is in Configuration or Command mode.

Chapter 4: Command Mode Operations

The following is a description of the various commands that the module accepts and the operations that it will perform while in Command Mode. When switching from Configuration Mode to Command Mode, the position will be invalid and the Current Position will be zero.

Absolute & Relative Moves

The current position <u>must</u> to be valid in order to perform an ABSOLUTE MOVE. A HOME or PRESET operation will have to be performed before the position becomes valid. The distance moved, that is the number of steps issued by the 3601, is equal to the difference between the Target Position and the Current Position. For example, if the Current Position is 5000, and the Target Position is 7500, than the unit will output 2500 steps. After the Absolute Move has been completed, the Current Position will be 7500. The direction of motion of an Absolute Move is determined by the relationship between the Current Position and Target Position. If the Target Position > Current Position, than CW motion will occur. If the Target Position < Current Position, than CCW motion will occur.

The current position does not have to be valid to perform a RELATIVE MOVE. The Target Position defines the distance, in number of steps, to travel relative to the Current Position. For example, if the Current Position is 5000 and the Target Position is 7500, than the unit will output 7500 steps. After the Relative Move has been completed, the Current Position will be 12,500.   The direction of motion of a Relative Move is selected by the sign of the Target Position. A positive Target Position will generate a CW move while a negative Target Position will generate a CCW move.

The ABSOLUTE or RELATIVE MOVE operations can produce two different velocity profiles. Normally the move operations start at the Starting Speed, accelerate to the Programmed speed at the defined acceleration rate, continue at the Programmed speed until it is time to decelerate back to the Starting Speed, and Stop. This generates a trapezoidal velocity profile.

However, if the move operation does not reach the Programmed speed by the time the deceleration is to begin, the move is decelerated to the Starting Speed and Stopped. In this way a triangular velocity profile is generated.

If the move operation runs to completion without error, the MOVE COMPLETE FLAG is set. If an error does occur, the MOVE COMPLETE FLAG will not be set, and an error flag will be set.

It is possible to hold both Absolute or Relative moves either by issuing a backplane Hold Command or activating the External Input. If the External Input is active when the Absolute or Relative move is initiated, you will get one step in the specified direction before the 3601 module goes into a hold state.

Hold Move

The HOLD MOVE command causes the move operation to decelerate at the programmed deceleration rate to the Starting Speed and stop. When this operation is successfully performed, the Hold State Input Bit is set. While the Hold operation is in affect, the velocity, acceleration, or deceleration parameters can be changed and the Resume Move command issued, or an entirely new move profile can be sent to the 3601 module.

- A Command Error will be generated if not all of the other command bits are reset when the Hold Command is issued.
- The 3601 module will ignore any change to the Target Position that is issued with the Resume Command.
- Any command, including an entirely new move command, can be issued while the 3601 module is in a Hold State. The module does not require that the Resume be the next command issued after the Hold command.
- Output words 1 to 7 do not have to be zero when the Hold command is issued.
- Homing operations cannot be held. If a Hold Move command is issued during a home operation, a Command Error will be generated and remain while the home will run to completion.
- Blend Moves cannot be held. If a Hold Move command is issued while a Blend Profile is running, the module will generate a command error, motion will continue until the profile is complete, when the Command Error bit will be reset.
- A Hold Move command issued during a manual move generates a command error and will cause the motion to stop.
- A Hold Move command issued during an Encoder Move operation will be ignored.
- A Hold Move command issued while the 3601 is in Encoder Follower mode will cause a command error to be generated.
- If the External Input was used to place the 3601 module in a hold state, then the External Input must be off before another move operation can be performed.

Resume Move

The RESUME MOVE command resumes a previously held Absolute or Relative Move. If the Resume Move command is the first command issued after a Hold Move operation, and no errors have occurred, the Resume Move command will cause the stepper motor to restart from the point where it was stopped, and the Hold State Input Flag will go off. If Triangular S Curve or Trapezoidal S Curve acceleration is required, the appropriate acceleration type bit(s) must be set with the Resume Move bit. When the move operation has been successfully completed, the Move Complete Flag will be set.

A move operation can be held and resumed many times until one of the following has occurred:

- The move reaches its programmed target position
- An error condition has occurred
- Some other move operation is started

Immediate Stop

The Immediate Stop command causes the current move operation to stop without any deceleration. That is, the step signal is simply stopped. If motion was occurring when this command was issued, the current position will become invalid, and the Position Invalid Input Bit will be set. The channel will have to be Preset or Homed again before an Absolute Move operation can be performed. However, it will be possible to perform a Relative Move or a Manual Move after an Immediate Interrupt has occurred. There will be no changes to the Status Bits if the Immediate Stop command is issued when motion was not occurring.

Find Home +/(CW), Find Home -/(CCW)

There are four homing options available. They are,

Home Limit Switch Only
Home Limit Switch with a backplane Home Proximity bit.
Marker Pulse Home with the Home Limit Switch Input acting as a Home Proximity.
Marker Pulse Home with a backplane Home Proximity bit.

The function of the Proximity Input, whether it is a physical input or a backplane bit, is exactly as it seems. When Proximity Input is used, the 3601 module will ignore any transitions of the Home Input until it detects the proper transition on the Proximity Input.

When the homing operation is complete, the 3601 will set the At Home input bit, and then reset both the current position and the encoder position to zero. If the capture value is present, it too will be reset to zero.

When issuing a Find Home command, the Target Position registers must be equal to zero, the Programmed Speed must be greater than or equal to the Starting Speed, and the Acceleration and Deceleration parameters must be present.
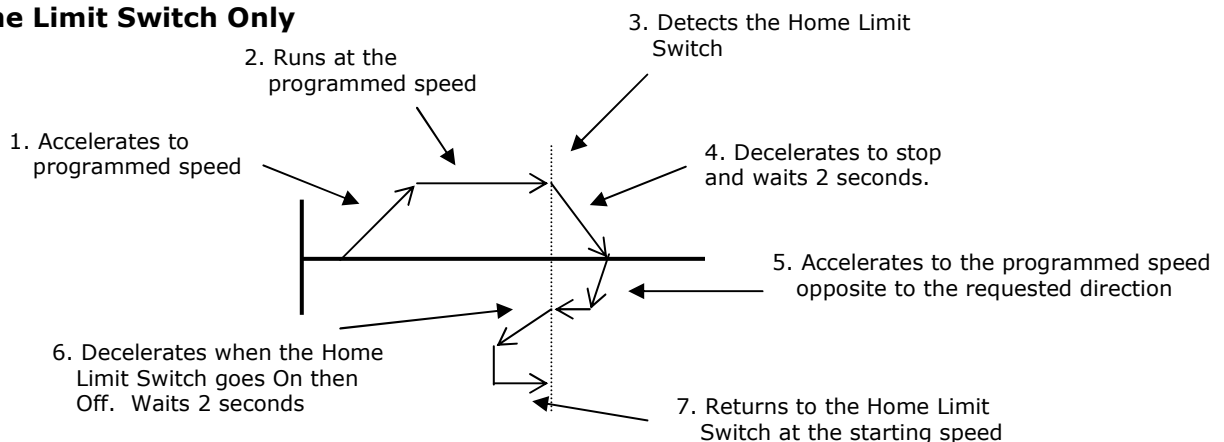
The Find Home commands require that at least one End Limit Switch, either CW or CCW, be configured. The 3601 will not accept a Find Home +/(CW) command when there is no CW Limit Switch configured. Likewise, it will not accept a Find Home -/(CCW) command when there is no CCW Limit Switch configured. If either of these operations are attempted, the COMMAND ERROR Input bit will be set.

S-Curve acceleration profiles are not allowed during a homing operation. Initiating a home operation with S curve accelerations will cause a command error to be generated.

If, during a Home operation, either of the End Limit Switch endpoints are reached, the module will stop outputting steps (essentially an emergency stop), wait for two seconds, reverse direction, and start searching for the appropriate homing signal again. It is important not to have the velocity set too high during a homing operation. The sudden stop and change in direction at high speeds may cause the motor to lock up.

The following diagrams illustrate the different homing options.

Home Limit Switch Only

3. Detects the Home Limit Switch
2. Runs at the programmed speed
1. Accelerates to programmed speed
4. Decelerates to stop and waits 2 seconds.
5. Accelerates to the programmed speed opposite to the requested direction
6. Decelerates when the Home Limit Switch goes On then Off. Waits 2 seconds
7. Returns to the Home Limit Switch at the starting speed

Backplane Home Proximity Bit with Home Limit Switch

2. Runs at the programmed speed

4. Detects backplane proximity bit and decelerates to the starting speed.

1. Accelerates to programmed speed

5. Runs at the starting speed.

6. Detects Home Limit Switch and stops.
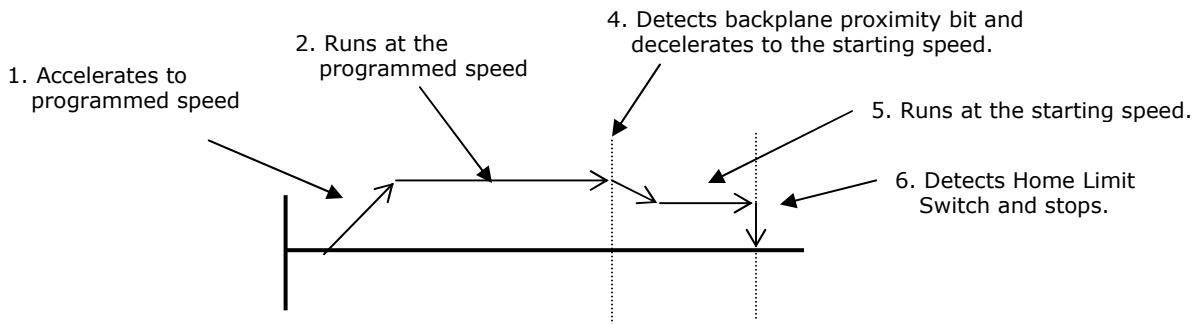
Marker Pulse and Proximity Switch (Either backplane bit or the Home Limit Switch treated as a Proximity Switch)

2. Runs at the programmed speed

3. Marker Pulse Ignored

4. Detects Proximity Switch and Decelerates to the starting speed

1. Accelerates to programmed speed

5. Runs at the starting speed.

6. Detects 1st Marker Pulse after the Proximity and Stops
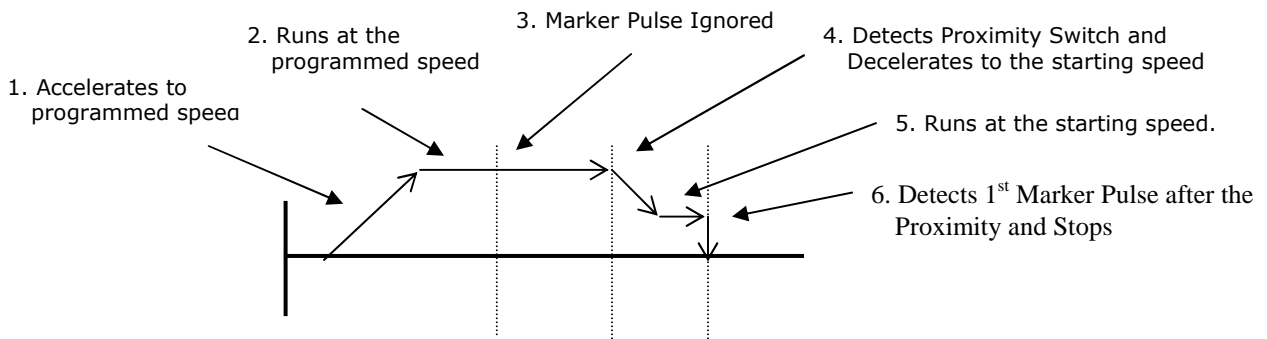
Reaching an End Limit Switch During a Homing Operation

1. Runs at the Programmed Speed

4. Waits for the Home Input to turn On then Off.

2. Reaches the end Limit Switch, stops without deceleration, and waits for two seconds

3. Turns at the programmed speed opposite to the requested direction

5. Returns at the starting speed to where the Home Input was detected. Continues to Marker Pulse or Home Limit Switch if applicable.
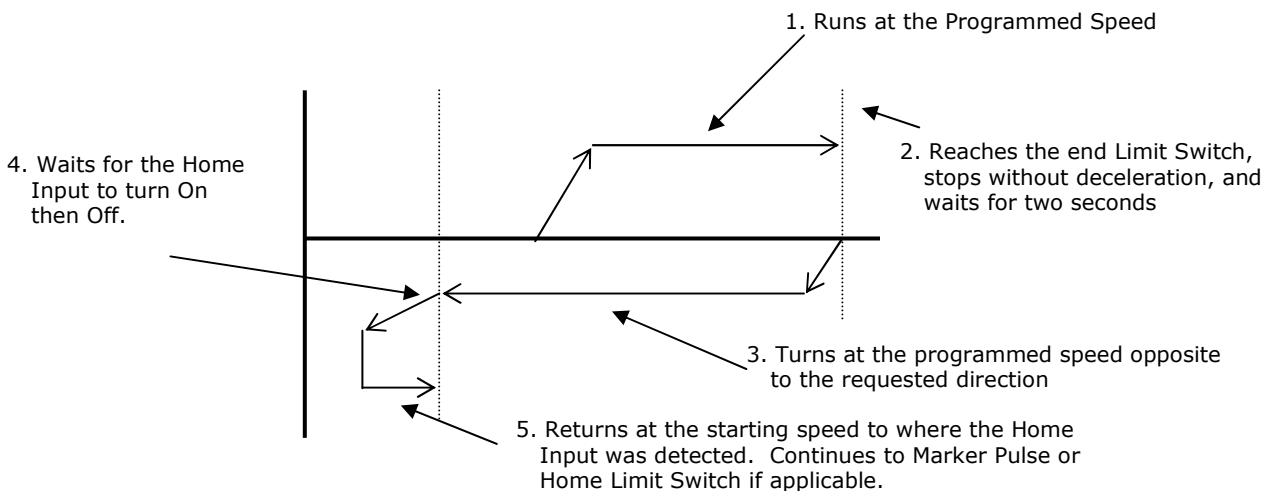
Note: The Home Input shown above can be either the Home Limit Switch or the Backplane Proximity bit.

Home Limit Switch Active when the Home Command is issued
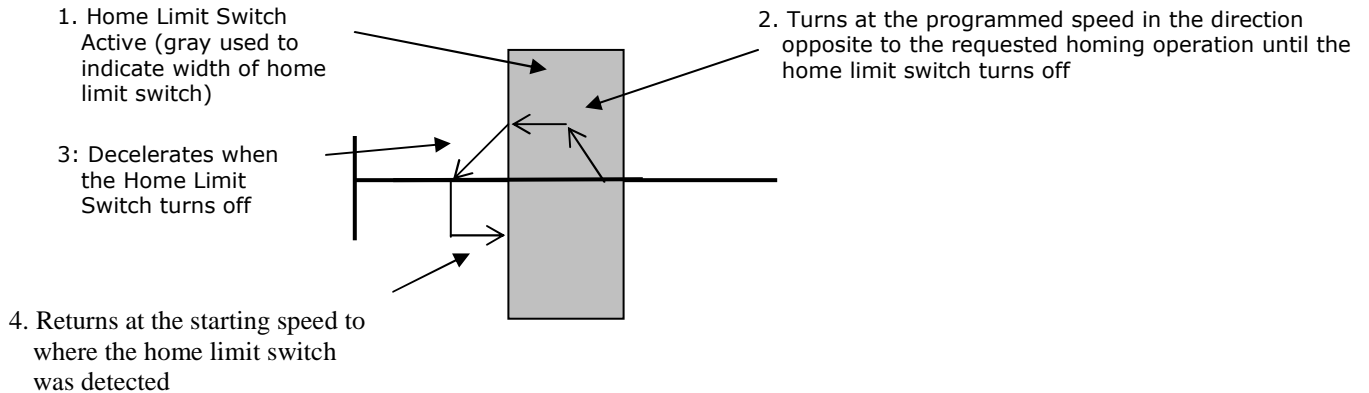
1. Home Limit Switch Active (gray used to indicate width of home limit switch)

2. Turns at the programmed speed in the direction opposite to the requested homing operation until the home limit switch turns off

3: Decelerates when the Home Limit Switch turns off

4. Returns at the starting speed to where the home limit switch was detected
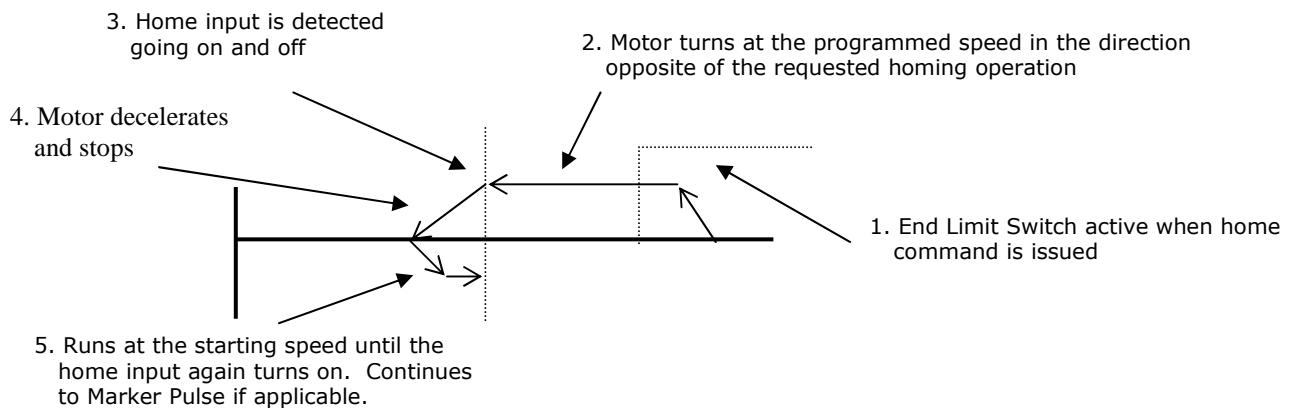
Note 1: The Home Input shown above can be either the Home Limit Switch or the Backplane Proximity bit.

Note 2: When backplane proximity homing, if the home limit switch is on when the home operation is started, the axis will turn opposite to the commanded direction until the home proximity bit, not the home input, has transitioned from ON to OFF.

End Limit Switch Active when the Home Command is issued

3. Home input is detected going on and off

2. Motor turns at the programmed speed in the direction opposite of the requested homing operation

4. Motor decelerates and stops

1. End Limit Switch active when home command is issued

5. Runs at the starting speed until the home input again turns on. Continues to Marker Pulse if applicable.

Note 1: The Home Input shown above can be either the Home Limit Switch or the Backplane Proximity bit.

Note 2: The above diagram is only true if the active End Limit Switch is the same as the issued home command, for example if the CW Limit Switch is active and a CW home command is issued. If the CW Limit Switch is active and a CCW home command is issued, than the unit will home normally, as if the end limit switch was not active.

Manual Move +/(CW), Manual Move -/(CCW)

This command performs the Manual Move operation at the programmed speed in the specified direction. Motion will occur as long as the command bit remains set. The Target Position register <u>must be zero</u> during all Manual Move operations. The state of the Encoder Move command bit is ignored when performing a Manual Move.

If the programmed speed is less than or equal to the starting speed, the starting speed is not used and the acceleration and deceleration parameters are ignored. The motor will "jump" to and run at the programmed speed without any acceleration. The speed cannot be changed when the module is running in this "constant speed mode." If it is, a Command Error and an Invalid Profile Error will be generated and the motion will be stopped.

If the programmed speed is greater than the starting speed, the axis begins the move at the starting speed, accelerates until the programmed speed is reached, and continues to move at the programmed speed until one of the following occurs:

-The Manual Move command bit is turned off
-The External Input, if configured, is activated
-The Immediate Stop output bit is set
-The Emergency Stop Input is activated
-The End Limit Switch in the same direction as the motion is reached
-The Programmed speed Changes

When stopping a Manual Move, <u>only</u> the Command Word should be reset to zero. A command error will be generated if all eight of the data words are reset to zero.

If the Manual Move command bit is turned off or if the External Input is active, the axis will decelerate at the programmed rate to the starting speed and stop, retaining a valid position. If the Immediate Stop Output bit or the Emergency Stop Input is used, the axis will stop without deceleration and the position will become invalid.

If the initial programmed speed is greater than the starting speed, the speed of a Manual Move operation can be changed without stopping the motion. If the velocity data is changed while the axis is moving, the module will accelerate or decelerate to the new speed, which can be less than the starting speed. The acceleration and or the deceleration parameters can also be changed, although these changes do not take affect until the programmed speed is changed. Both the acceleration and deceleration parameters must be valid when the speed is changed. If the changed velocity, acceleration, or deceleration parameters are invalid, the 3601 module will immediately decelerate and stop and both the Command and Invalid Profile error bits will be set.

An additional feature of the Manual Move parameter is the ability to do a One Shot Manual Move. With the programmed speed set to zero, a $0 \rightarrow 1$ transition of the Manual Move bit will cause the stepper controller to output 1 pulse in the specified direction. Please note that in One Shot Manual Move mode, the Motion Direction bit will remain on and the Status LED will flash as long as the Manual Move command bit remains set.   The Stopped status bit will not be set when the Manual Move command bit is reset.

If the End Limit Switch in the same direction as motion is reached during a Manual Move, the axis will stop without deceleration and the input error and position invalid input bits will be set. For example, reaching the CW Limit Switch during a CW Manual Move will stop the motion. However, an End Limit Switch in the direction opposite to motion <u>will not stop</u> a Manual Move

operation. For example, reaching the CCW Limit Switch during a CW Manual Move. This feature allows the module to be moved off of an active end limit switch.

Preset Current Position and Diagnostic Feedback Position

This command will set the Current Position, and the Diagnostic Feedback value if appropriate, to the value present in the Target Position Registers. If the position is currently invalid, presetting the position will cause the position to become valid. The programmed speed, acceleration, and deceleration parameters <u>must be zero</u> when this command is sent to the module.

Preset Encoder Position

This command will set Current Encoder Value to the value present in the Target Position registers. The 3601 module must be configured to use an encoder, and the programmed speed, acceleration, and deceleration parameters <u>must be zero</u> when this command is sent to the module.

Reset Errors

This command clears all nonfatal errors detected by the stepper controller. A nonfatal error is one that can be recovered from. For example, trying to perform an Absolute Move when the position is not valid is a nonfatal error. The Lower Command Word <u>must be zero</u> when the Reset Errors command is issued. When there is a Command Error, the controller will not perform any other operations until the Reset Errors command is issued.

General Command Mode Operation Notes

1. Only a single bit can be set at any one time in the Most Significant Command Word. For this reason, AMCI recommends that MOV, COP, or CPS instructions for CompactLogix PLCs, be used to send commands to the 3601 module.
2. A Command Error will be generated if a move operation is started before the previous move operation is completed. A move operation should only be started if the Move Complete, Stopped, or Hold status bits are set.
3. Only a 0 to 1 transition of any of the control bits listed above will cause the specified operation to take place.
4. If either the CW or CCW Limit Switches are reached during a normal move or manual move operation, the module will treat the input as an emergency stop, meaning that the motor will stop and the position will become invalid.
5. It is possible to home the 3601 module off of an end limit switch.
6. Sample Programs for both the Compact and MicroLogix 1500 systems are available from the following page of our website; http://www.amci.com/sampleprograms.asp

Blend Move

This command allows the user to create more complicated move profiles consisting of two to sixteen segments, as the following diagram illustrates.
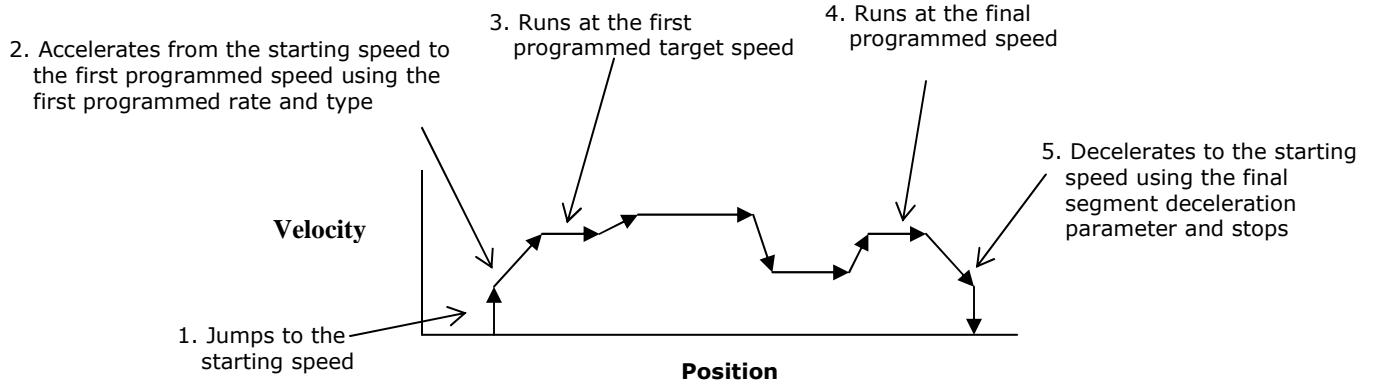
Each segment is defined by four parameters:

1. Acceleration Type (Constant, Triangular S Curve, or Trapezoidal S curve)
2. Relative Segment Length
3. Target speed
4. Acceleration/Deceleration Rate

The minimum amount of information necessary to define a new move segment is the Target Speed. The Segment Length and the Acceleration/Deceleration rate do not have to change from one segment to the next. An Invalid Profile Error will be generated if the Target Speed parameter is not different in two consecutive blend move segments.

The blend move programming is done at one time, with the segments of the blend move profile stored in the internal memory of the 3601. This data will remain in the module's memory until power is removed from the module, the configuration data is programmed, or a new blend move profile is sent to the unit.

The Blend Move Profile is programmed as a series of Relative Moves (segments), so the position does not have to be valid for the blend move operation to take place. The first segment starts at the Starting Speed and accelerates to the specified Programmed speed. The starting speed for the next segment is equal to the programmed speed of the current segment. The final segment will decelerate from the final programmed speed to the starting speed and then stop. It is not possible to program a direction reversal in the blend move profile.

Because the 3601 module stores the data for the Blend Move Profile in its memory, the programmed profile can be run more than once and from any location. Two command bits allow the blend move profile to be run in either direction. Please note that it is possible to perform other move or home operations between performing the blend move profiles.

Registration Move

This feature is only available with the Version 3.1 and higher firmware, starting with serial number 96317.

The Registration Move function modifies the Manual Move function so that a programmed number of steps will be output after the 3601 module has received either a command or an input signal to stop.

- If a manual move operation is initiated and the target position registers are zero, the Manual Move will occur exactly as described earlier in these specifications.
- If a manual move operation is initiated and the target position registers are not zero, the number of steps entered will be output at the end of the Manual Move. As shown in the following diagram, this number of steps also includes the time to decelerate and stop.
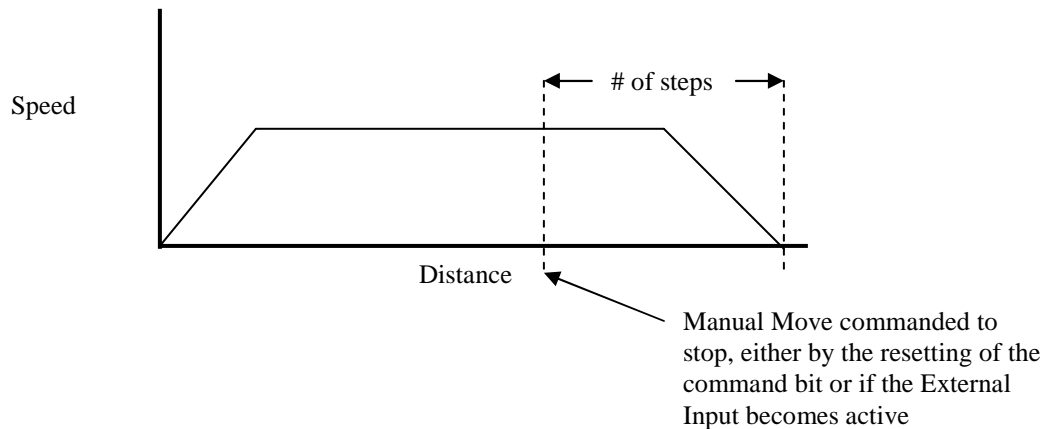
An additional feature of the 3601 module's Registration Move function is the ability to program the module to ignore the external input or the resetting of the Manual Move Command until a certain number of steps have been output from the 3601 module. This parameter is called the Minimum *Registration Move Distance,* is programmed separately, and is stored in the 3601 module's memory.
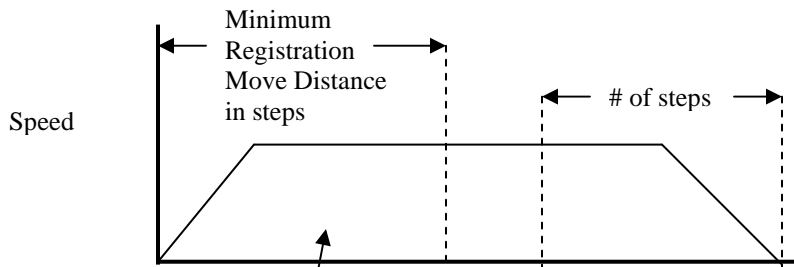
The following considerations and restrictions must be observed when using the 3601 module to perform a Registration Move.

- A registration move can be performed by either resetting the Manual Move command bit or by activating the External Input. For the remainder of this section, this will be referred to as the Registration Input.
- The number of steps entered in the Target Position registers <u>cannot</u> be changed while a Registration Move is occurring.
- While a Registration Move is occurring, but before the Registration Input has been detected, the Programmed Speed can be reduced from its original value. However, increasing the Programmed speed will cause an error to be generated.
- Any changes to the programmed speed parameter will be ignored once the Registration Input has been detected.
- Changing the acceleration or deceleration values while a Registration Move is occurring is not allowed. However, an error will be generated only if the Programmed Speed parameter is also changed.
- A Registration Move <u>must</u> be based on the number of steps output from the 3601 module. It cannot be run as an Encoder move.

- The Minimum Registration Move parameter defines the number of steps relative to the starting position of the Registration Move. It is <u>not</u> based on the absolute position of the current position value.
- When the Minimum Registration Move parameter is not zero, the 3601 module will ignore both the External Input and the resetting of the Manual Move command bit until the number of steps output exceeds the Minimum Registration Move distance.
- The Registration Input is level triggered. That is, the input must be active or the command bit reset past the Minimum Registration Move distance. There does not have to be a transition past this point.
- The Minimum Registration Move parameter is programmed before the registration move begins and is stored in the 3601 module's memory. Once programmed, registration moves can be run repeatedly based on this value.
- The Minimum Registration Move parameter has a range of 0 to 8,388,607 and <u>must</u> be positive. Entering a value of zero disables the function of the Minimum Registration Move value.
- The Minimum Registration Move parameter will be reset to zero both at power up or after a configuration operation has occurred.
- As with the manual move, the opposite end limit switch will not stop a registration move. For example, the CCW Limit Switch will not stop a registration move in the CW direction.

The following is a list of the Output Command bit and the Input Status bits that are specific to the Registration Move function, and are only available on 3601 modules that have version 3.1 or higher firmware, starting with serial number 96317.

New Command Bit
Programs the Minimum Registration Move Distance

Program Minimum Registration Move Distance (range of 0 to 8,388,607)

Output Word(s)	Function
0	Must Be Zero
1	Bit 10 set (value of 1024 decimal)
2	Most Significant Word of the Minimum Registration Move Distance
3	Least Significant Word of Minimum Registration Move Distance
4 to 7	Must Be zero

New Command Mode Status Bit
Indicates that the Minimum Registration Move distance is not zero

Input Word 1, bit 10

New Error Bit Functions

When performing a Registration Move, the following conditions will set the *Command Error bit* (MSW Status Word, bit 12).

- If the Minimum Registration Distance is outside of the valid range or is negative.
- A Hold Command issued while a registration move is occurring will cause a command error to be generated. The deceleration value will be used to perform a controlled stop of the motion.

When performing a Registration Move, the following conditions will set both the *Command Error bit* (MSW Status Word, bit 12) and the *Invalid Profile bit* (MSW Status Word, bit 9).

- If the Registration Move is started with the External Input active. This is also true if the Minimum Registration Move Distance is being used.
- If the number of steps programmed into the target position registers is less than the number of steps required to decelerate and stop the motion. In this case the Registration Move will not start.
- If the number of steps programmed into the target position registers is negative.
- If a value is entered in the target position registers while a standard Manual Move is occurring. Motion will immediately stop.
- If the value of the target position registers is changed after a Registration Move has been initiated. Motion will immediately stop.
- Increasing the speed of a Registration Move while it is occurring. Motion will immediately stop. Please note that it is possible to decrease the speed of Registration Move while it is occurring.
- Changing the acceleration or deceleration parameters while also changing the Programmed Speed during a Registration Move. Motion will immediately stop.

Encoder Move

The 3601 module has the ability to perform an Encoder Move, where the number of counts made by an incremental encoder determines the distance of the move. If bit 2 of command word 1 is set when an absolute or relative move is initiated, the 3601 module will begin a move profile using the programmed velocity and acceleration parameters. The programmed position is now the number of encoder counts to move. When this encoder count is reached, the 3601 module will begin to decelerate at the programmed deceleration rate, and stop. After motion has stopped, the 3601 module will set status bit 7, the Move Complete bit.

The following must be considered when using the Encoder Move function.

- An Encoder Move <u>does not stop at the target position</u>. It will overshoot the target position because it begins to decelerate at the target position
- The 3601 module uses X4 decoding on the encoder inputs, so the number of counts per turn of the encoder will be four times the encoder's resolution. For example, if a 1000 line encoder is being used, the 3601 will report 4000 counts per turn. This is the number that must be used when determining the position data of your encoder move.
- Absolute Encoder moves will be negative, motion in the Counter Clockwise direction, if the target position is less than the current encoder position.
- Relative Encoder moves will be negative, motion in the Counter Clockwise direction, only if the target position is negative.
- If the 3601 module is not configured to accept encoder inputs, attempting an encoder move will cause a command error to be generated.
- It is not possible to hold an encoder move. A backplane hold command issued during an encoder move will be ignored.
- Activating the External Input during an encoder move will cause the module to execute a controlled stop.
- Setting bit 2 of the LSW command word (the encoder move command bit) during a manual move or home operation will not have any affect on the 3601 module's profile.
- Before performing a Target Position absolute or relative move, it will be necessary to reset bit 2 in the LSW command word.
- An Encoder Move will take place even if a working encoder is not attached to the module or if the motor stalls. If this occurs, motion will continue until an Emergency Stop Input, the External Input, or an Immediate Stop command stops it.
- Do not reset the LSW command word while an Encoder move is occurring. If both the MSW and LSW command words are reset to zero while an encoder move is occurring, than the 3601 module will shoot past the target encoder count value. If only the MSW is reset while an encoder move is occurring, than the encoder move will correctly run to completion.

Diagnostic Feedback

By wiring the pulse and direction outputs to the encoder inputs, this feature can be used to verify program and module operation. When in diagnostic feedback mode, the module counts its own steps and reports the position data in the Current Encoder/Diagnostic Feedback input register.

The maximum input frequency that the module can accurately measure in Diagnostic Feedback mode is 500kHz.

Encoder Follower Function

This feature is only available with the Version 4.1 and higher firmware, starting with serial number 04060162.

In Encoder Follower mode, the 3601 module follows the signals that it receives on its encoder inputs. That is, it will output a step only when a pulse is received on its inputs. Also, through the use of multiplier and divisor values, it is possible to have the module output steps faster or slower than the rate of the incoming encoder pulses. The following table shows how the 3601 module's output registers are used in Encoder Follower mode.

16 bit Output Word	Standard Function	Encoder Follower Function	Encoder Follower Range
0	Command MSW	Command MSW	Bit 7 or Bit 8 set
1	Command LSW	Command LSW	Bit 7 set
2	Target Position MSW	Multiplier	1 to 32767
3	Target Position LSW	Divisor	1 to 32767
4	Programmed Speed MSW	Must be zero	0
5	Programmed Speed LSW	Must be zero	0
6	Acceleration	Acceleration	0 to 2000
7	Deceleration	Deceleration	0 to 2000

Two bits are used to control the encoder follower mode operations. First, bit 7 of the Least Significant Command Word, Output Word 1, places the module in Encoder Follower mode. The 3601 will set bit 7 of the Least Significant Status word (Input Word 1 bit 7) to indicate that the 3601 module is operating as an Encoder Follower.

Second, the Encoder Follower function uses the Manual Move command bits to select the direction of travel. If the Manual Move + (CW) command is used, than the 3601 will output steps in the same direction as the encoder signals. If the Manual Move – (CCW) command is used, than the 3601 will output steps in the opposite direction from the encoder signals. No motion will occur if neither of the Manual Move Command bits are set.

The Encoder Follower Multiplier and Divisor values have a range of 1 to 32767 and can be changed while an encoder follower operation is occurring.

As with all of the 3601's encoder functions, X4 decoding is used to decode the encoder's position. This decoding type must be taken into account when calculating the appropriate multiplier and divisor values.

The Programmed Speed parameter registers, output words 4 and 5, must be zero or the 3601 module will generate a Command Error.

The Encoder Follower function can also use the Acceleration and Deceleration parameters. If these parameters are zero, the 3601 module will jump from its current speed to its new speed without any acceleration, which may stall the motor. If the acceleration and deceleration parameters are not zero, the 3601 module will use these parameters to reach the required speed. S Curve accelerations cannot be used in Encoder Follower mode.

Encoder Follower functions cannot be started when either of the end limit switches are active.

Encoder Follower Considerations

- Even if motion is not occurring, the Axis OK LED will blink green when the 3601 module is in Encoder follower mode.
- To have the 3601 module exactly follow the encoder signals on its inputs, the acceleration and deceleration parameters should be set to zero. However, if this causes the motor to stall, set the acceleration and deceleration parameters to the maximum value of 2000 and try running the machine again. If this still causes the motor to stall, decrease the values of the acceleration and deceleration until the motor is running correctly.
- If the acceleration and deceleration parameters are set to zero, and if there is no motion occurring on the master device, then electronic noise on the encoder inputs may cause the follower motor to oscillate back and forth by ± 1 step.
- The 3601 module will always output the correct number of steps when operating in encoder follower mode. However, the use of acceleration and deceleration values, especially if very low numbers are used, will cause the encoder follower's motion to take longer to occur than the pulses supplied on the encoder inputs.

New Error Bit Functions

While in Encoder Follower mode, the following conditions will cause the 3601 module to set the *Command Error bit* (Status Word 1, bit 12). Unless otherwise stated, the 3601 module will stop outputting steps if motion was taking place when any of these error conditions occurred.

- If the 3601 module is placed in Encoder Follower mode, by setting output word 1 bit 7, without first configuring the module to use an encoder.
- Trying to place the 3601 module in Encoder Follower mode with motion already occurring. Please note that even though the command error status bit will be set, the original move operation will run to completion.
- If the multiplier or divisor values are outside of the range of 1 to 32767.
- If the Programmed Speed registers, output words 4 and 5, are not equal to zero.
- If the direction of the Encoder Follower motion is changed, by changing which Manual Move command bit is set, without at least one I/O scan where the command word is equal to zero.
- If any command is issued, including the Hold Command, when the 3601 module is in Encoder Follower mode. That is, if any of the bits in the MSB Command Word other than Manual Move + or Manual Move – are set when the Encoder Follower Bit (output word 1 bit 7) is set.
- While operating in Encoder Follower Mode, if the Encoder Follower Bit (output word 1 bit 7) is reset while the Manual Move Command bit remains set.
- Selecting S curve acceleration with Encoder Follower mode.

Acceleration Types

With the exception of Homing and Encoder Follower operations, all of the move operations defined above allow the type of acceleration to be selected. The three options are described below.

Constant Acceleration: The module accelerates at a constant rate until the programmed speed is reached.
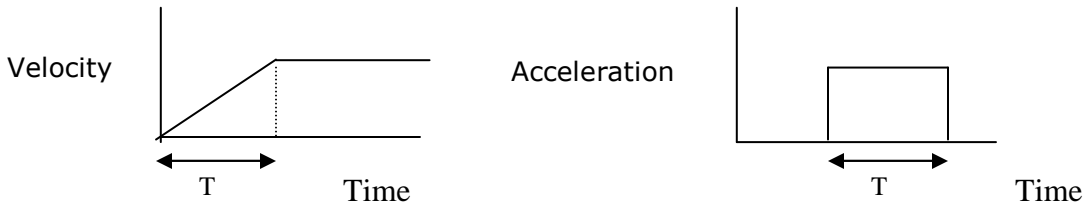
Triangular S Curve Acceleration: The module accelerates slowly at the beginning of the acceleration, faster at the middle of the acceleration, and again slowly at the end of the acceleration. The acceleration rate is never constant.
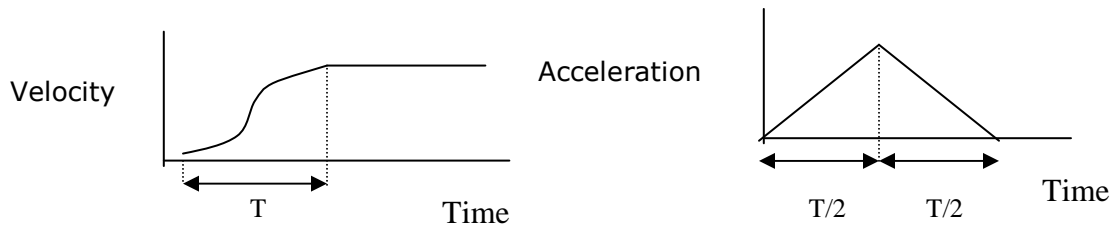
Trapezoidal S Curve Acceleration: The module accelerates slowly at the beginning of the acceleration, at a constant rate at the middle of the acceleration, and again slowly at the end of the acceleration.
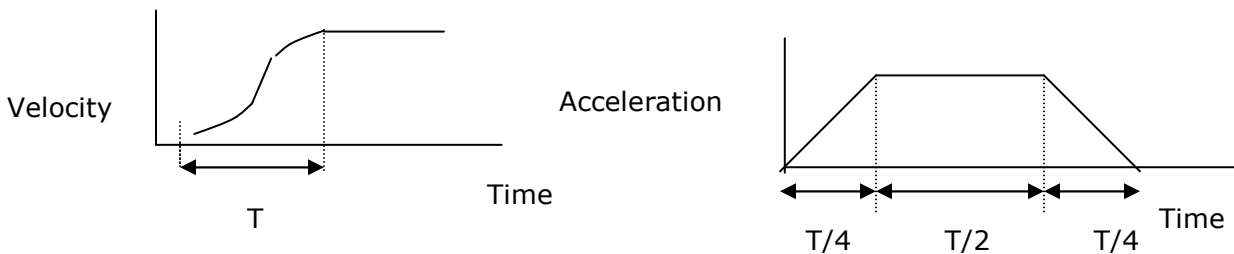
Notes:

1. The defined acceleration type is also applied to the deceleration.
2. Constant acceleration has the shortest acceleration time and Triangular S Curve has the longest acceleration time.
3. The constant portion of the Trapezoidal S Curve Acceleration is 50% of the total acceleration time.

Chapter 5: Command Mode Output Data
(Eight 16 bit words sent from the PLC to the 3601 module)

All stepper motor operations are performed in command mode. This mode is entered, after a successful configuration file has been transferred to the stepper controller by resetting the Mode Flag bit 15 of Output Word 0. In Command Mode, the PLC program can issue commands and activate different operations or moves. A move profile typically consists of a Target Position, Programmed Speed, Acceleration, and Deceleration parameters. The following table shows the function of the output words.

If 3601 module was added to a CompactLogix system using the Generic Module Profile, these words will be defined as Local:X:O.data[0] to Local:X:O.data[7]. In a MicroLogix 1500 system, these words will be defined as O:X.0 to O:X.7. In both cases, the "X" indicates the slot number. The following table shows the layout of the output registers if the 3601 module was added to the a CompactLogix or MicroLogix 1500 systems using the Generic Module Profile

Generic Output Data

16 bit Output Word	Function	Units	Range
0	Command MSW		See description below
1	Command LSW		See description below
2	Target Position MSW	Steps	-8,388,608 to 8,388,607
3	Target Position LSW		
4	Programmed Speed MSW	Steps/Second	Starting Speed to 1,000,000
5	Programmed Speed LSW		
6	Acceleration	Steps/ms/sec	1 to 2000
7	Deceleration	Steps/ms/sec	1 to 2000

The following table shows how the 3601's output registers will appear if the module was added to the CompactLogix I/O using the profile available in RSLogix 5000 V20 or above.

−Local:1:O	{...}	{...}		AM:1769_3601:O:0
+ Local:1:O.Data0	0		Decimal	INT
+ Local:1:O.Data1	0		Decimal	INT
+ Local:1:O.Data2	0		Decimal	INT
+ Local:1:O.Data3	0		Decimal	INT
+ Local:1:O.Data4	0		Decimal	INT
+ Local:1:O.Data5	0		Decimal	INT
+ Local:1:O.Data6	0		Decimal	INT
+ Local:1:O.Data7	0		Decimal	INT

Command Mode Programming Information

1. Only a single bit can be set at any one time in the Most Significant Command Word. For this reason, AMCI recommends that MOV, COP, or CPS instructions for CompactLogix PLCs, be used to send commands to the 3601 module.
2. A Command Error will be generated if a move operation is started before the previous move operation has completed. A move operation should only be started if the Move Complete, Stopped, or Hold status bits are set.
3. A negative Target Position value will be programmed as a negative decimal number in both the MSW and LSW data words. For example;

Value	MSW	LSW
-12,345	-12	-345
12,000	12	0
-12,000	-12	0
345	0	345
-345	0	-345

4. The Position parameter has a range of $-8,388,608 \leq$ Target Position $\leq 8,388,607$.
5. The LSW of the Target Position has a range of -999 to $+999$.
6. The Programmed Speed has a range of Starting Speed $\leq$ Programmed Speed $\leq$ 1,000,000 steps/sec.
7. The LSW of the Programmed Speed has a range of 0 to 999.
8. The acceleration and deceleration parameters have a range of $1 \leq$ acceleration / deceleration $\leq 2,000$ and is measured in steps/msec/sec. Multiply the acceleration rate by 1000 to convert it from steps/ms/sec to steps/sec/sec.
9. Switching the PLC to Program Mode will cause any move operation to stop and the position to become invalid.
10. Sample Programs for both the Compact and MicroLogix 1500 systems are available from the following page of our website; http://www.amci.com/sampleprograms.asp

Command Word MSW

Bit 0 = set to perform an ABSOLUTE MOVE operation
Bit 1 = set to perform a RELATIVE MOVE operation
Bit 2 = set to perform a HOLD MOVE operation
Bit 3 = set to perform a RESUME MOVE operation
Bit 4 = set to perform an IMMEDIATE STOP operation
Bit 5 = set to perform a FIND HOME +/(CW) operation
Bit 6 = set to perform a FIND HOME -/(CCW) operation
Bit 7 = set to perform a MANUAL MOVE +/(CW) operation
Bit 8 = set to perform a MANUAL MOVE -/(CCW) operation
Bit 9 = set to PRESET the Current Position and if appropriate the Diagnostic Feedback data
      (This bit does not reset the Move Complete input bit)
Bit 10 = set to PRESET optical encoder
Bit 11 = set to perform a RESET ERRORS operation
Bit 12 = set to RUN BLEND MOVE PROFILE in the positive direction
Bit 13 = set to RUN BLEND MOVE PROFILE in the negative direction
Bit 14 = reserved;
Bit 15 = MODE FLAG: "1" for Configuration Mode "0" for Command Mode

Command Word LSW

Bit 0 = reset for CONSTANT ACCELERATION, set for S-CURVE ACCELERATION

Bit 1 = reset for TRIANGULAR S-CURVE ACCELERATION, set for TRAPEZOIDAL S-CURVE ACCELERATION.   This bit is only valid if bit 0 of the LSW is set.

Bit 2 = reset for a TARGET POSITION move, set for an ENCODER COUNT move

Bits 3 to 6 = Reserved

Bit 7 = Set to enable Encoder Follower Mode (This function is available only on 3601 modules with serial numbers greater than 04060162.)

Bit 8 = set to PROGRAM a BLEND MOVE PROFILE. This bit must remain on while the Blend Move Profile segments are being programmed.

Bit 9 = BLEND MOVE TRANSMIT bit

Bit 10 = Set to store the MINIMUM REGISTRATION MOVE distance that is located in the Target Position Registers. This function is available only on 3601 modules with serial numbers greater than 96317.

Bit 11 = Reserved

Bit 12 = BACKPLANE HOME PROXIMITY bit. When set by the PLC, this bit causes the rate at which a homing operation is occurring to change from the Programmed Speed to the Starting Speed. The 3601 module will ignore the state of this bit unless the module was configured to accept backplane home proximity operations, and if there is no homing operation taking place.

Bits 13 to 15 = Reserved.

> **Note:** The bits in the LSW must be reset when single bit commands in the MSW are issued. For example, the LSW must be zero when the Reset Errors, Preset Position, or a Run Blend Move command s issued. The LSW does not have to be zero during Absolute, Relative, or Manual moves.

Blend Move Programming

A Blend Move consists of two to sixteen segments made up of a Relative Segment Length, a Target Velocity, and an Acceleration/Deceleration value. The blend move operation will be run each time bit 12 or 13 in the output Command Word MSW 1 transitions from 0 to 1.

When bits 8 and 9 of the LSW Command Word are first set, the module reads the first of the blend move programming blocks and sets the BLEND MOVE ACKNOWLEDGE bit (bit 9 of LSW Status word). While leaving bit 8 set, resetting bit 9 (the BLEND MOVE TRANSMIT bit) causes the 3601 module to reset the BLEND MOVE ACKNOWLEDGE bit. Each additional 0 to 1 transition of the BLEND MOVE DATA VALID bit causes the module to read the next segment of the blend move programming data.

The following table shows the layout of the Blend Move data sent to the module.

BLEND MOVE DATA – FIRST PROGRAMMING BLOCK

Word	Function
0	Command word MSW
1	Command word LSW
2	Number of Segments
3	Acceleration Type MSW (segments 9 to 16)
4	Acceleration Type LSW (segments 1 to 8)
5	Final Segment Deceleration & Acceleration Type
6	0
7	0

BLEND MOVE DATA – PROGRAMMING BLOCKS 2…17

Word	Function
0	Command word MSW
1	Command word LSW
2	Segment Length MSW
3	Segment Length LSW
4	Target Speed MSW
5	Target Speed LSW
6	Acceleration/Deceleration
7	0

Number of Segments

This parameter defines the number of blend move segments that are being programmed. This parameter has a range of 2 to 16. A value outside of this range will generate an Invalid Profile Error.

Acceleration Type

Every two bits in these words define the acceleration type of each segment. When the least significant bit of the two is reset, the acceleration type of the segment will be Constant. When the least significant bit of the two is set, the state of the most significant bit determines the type of S curve acceleration. If the most significant bit is reset, triangular S curve acceleration will be used. If the most significant bit is set, trapezoidal S curve acceleration will be used. The following table shows an example of how the bits in this word are used.

Segment Length Restrictions

- The sum of all of the segment lengths cannot exceed 8,388,607.
- The segments must be positive.
- The LSW of the segment length has a range of 0 to 999.

Word	Segment	MSB of pair	LSB of pair	Function
LSW	1 Bits 1 & 0	0	0	Constant Acceleration
		0	1	Triangular S Curve Acceleration
		1	1	Trapezoidal S Curve Acceleration
	2 Bits 3 & 2	0	0	Constant Acceleration
		0	1	Triangular S Curve Acceleration
		1	1	Trapezoidal S Curve Acceleration

Word	Segment	MSB of pair	LSB of pair	Function
MSW	15 Bits 13 & 12	0	0	Constant Acceleration
		0	1	Triangular S Curve Acceleration
		1	1	Trapezoidal S Curve Acceleration
	16 Bits 15 & 14	0	0	Constant Acceleration
		0	1	Triangular S Curve Acceleration
		1	1	Trapezoidal S Curve Acceleration

Final Segment Deceleration & Acceleration Type

This word defines the deceleration rate between the final segments programmed speed and the starting speed and has a range of 1 to 2000. The two Most Significant bits in this 16 bit-word also define the deceleration type.

Bit 15	Bit 14	Function
0	0	Constant Acceleration
0	1	Triangular S Curve Acceleration
1	1	Trapezoidal S Curve Acceleration
1	0	Invalid Acceleration type

A Command Error will be generated if the Final Segments Deceleration value is not programmed.

Acceleration/Deceleration Parameters

This parameter defines the rate of change of the speed between two adjacent segments. If the speed in the next segment is greater than the speed in the current segment, then this parameter will be used as an acceleration value. If the speed in the next segment is less than the speed in the current segment, then this parameter will be used as a deceleration value.

BLEND MOVE PROGRAMMING ROUTINE

The following is a description of how the Blend Move Profile will be programmed. For this description, the module is plugged into slot 2 of the CompactLogix rack.

1. The PLC writes the first programming block and sets the PROGRAM BLEND MOVE PROFILE bit (output word 1 bit 8) and the BLEND MOVE TRANSMIT bit (output word 1 bit 9)
2. The 3601 module responds by setting the BLEND MOVE ACKNOWLEDGE bit, input word 1 bit 9. If an error is detected, it will set the INVALID PROFILE bit, input word 0 bit 9, and turn on the Axis Error LED. If this occurs, the PLC processor will have to issue a RESET ERRORS command before any other operations can be performed.
3. When the PLC detects that the BLEND MOVE ACKNOWLEDGE bit is set, it resets the BLEND MOVE TRANSMIT BIT, output word 1 bit 9.
4. The 3601 module detects that the BLEND MOVE TRANSMIT bit is reset, and resets the BLEND MOVE ACKNOWLEDGE bit, input word 1, bit 9.
5. Steps 1 … 4 are repeated for the remaining data blocks until the entire blend move profile has been entered. The maximum number of segments per profile is 16.
6. After the last segment has been transferred, the PLC exits Blend Move Mode by resetting bit PROGRAM BLEND MOVE PROFILE bit, output word 1, bit 8.

Chapter 6: Command Mode Input Data
(Eight 16 bit words sent from the 3601 module to the PLC)

> Sample Programs for both the Compact and MicroLogix 1500 systems are available from the following page of our website; http://www.amci.com/sampleprograms.asp

The 3601 module uses eight 16 bit words to reports its data to the PLC. If 3601 module was added to a CompactLogix system using the Generic Module Profile, these words will be defined as Local:X:I.data[0] to Local:X:I.data[7]. In a MicroLogix 1500 system, these words will be defined as I:X.0 to I:X.7. In both cases, the "X" indicates the slot number. The following table shows the layout of the input registers if the 3601 module was added to the a CompactLogix or MicroLogix 1500 systems using the Generic Module Profile

Generic Input Data

16 bit Input Word	Configuration Input Data
0	Status Word MSW (see description below)
1	Status Word LSW (see description below)
2	Current Position MSW
3	Current Position LSW
4	Current Encoder / Diagnostic Feedback Data MSW
5	Current Encoder / Diagnostic Feedback Data LSW
6	Captured Data MSW
7	Captured Data LSW

The following table shows how the 3601's input registers will appear if the module was added to the CompactLogix I/O using the profile available in RSLogix 5000 V20 or above.

				AM:1769_3601:I:0
⊟ Local:1:I	{...}	{...}		
⊞ Local:1:I.Fault	0		Decimal	DINT
⊞ Local:1:I.Data0	0		Decimal	INT
─ Local:1:I.ConfigError	0		Decimal	BOOL
─ Local:1:I.ModuleOK	0		Decimal	BOOL
─ Local:1:I.ConfigMode	0		Decimal	BOOL
⊞ Local:1:I.Data1	0		Decimal	INT
⊞ Local:1:I.Data2	0		Decimal	INT
⊞ Local:1:I.Data3	0		Decimal	INT
⊞ Local:1:I.Data4	0		Decimal	INT
⊞ Local:1:I.Data5	0		Decimal	INT
⊞ Local:1:I.Data6	0		Decimal	INT
⊞ Local:1:I.Data7	0		Decimal	INT

Status Word MSW Layout

Bit 0 = set when the axis is moving CW

Bit 1 = set when the axis is moving CCW

Bit 2 = set when the stepper controller is in a HOLD STATE. This bit will be reset when the next move operation is taking place.

Bit 3 = set when the axis is STOPPED (This bit will not be set if the Move Complete, At Home, or Hold bits are set)

Bit 4 = set when the axis is AT HOME at the completion of a homing operation

Bit 5 = set when the axis is ACCELERATING

Bit 6 = set when the axis is DECELERATING

Bit 7 = set when MOVE COMPLETE. Valid only for Absolute, Relative, and Blend Moves.

Bit 8 = set when there is a HOME INVALID ERROR

Bit 9 = set when there is an INVALID PROFILE

Bit 10 = set when POSITION INVALID

Bit 11 = set when there is an INPUT ERROR. (This bit will be automatically reset when the next move operation is initiated. This bit will also be reset by a RESET ERRORS command.)

Bit 12 = set when there is a COMMAND ERROR. This bit must be reset before another command, including IMMEDIATE STOP, will be accepted

Bit 13 = set when there is a CONFIGURATION ERROR

Bit 14 = set when MODULE OK

Bit 15 = MODE FLAG "1" configuration mode, "0" for command mode

Status Word LSW Layout

Bit 0 = set when the CAPTURE INPUT is active

Bit 1 = set when the EXTERNAL INPUT is active

Bit 2 = set when the HOME LIMIT SWITCH input is active

Bit 3 = set when the EMERGENCY STOP input is active

Bit 4 = set when the CW LIMIT SWITCH input is active

Bit 5 = set when the CCW LIMIT SWITCH input is active

Bits 6 Reserved

Bit 7 = set when the 3601 module is in Encoder Follower Mode. (This function is available only on 3601 modules with serial numbers greater than 04060162.)

Bit 8 = set when the stepper controller is running a BLEND MOVE profile

Bit 9 = BLEND MOVE to ACKNOWLEDGE bit, set when the 3601 has received a blend move programming block

Bit 10 = set when a non-zero Minimum Registration Move Distance parameter has been programmed. This function is available only on 3601 modules with serial numbers greater than 96317.

Bit 11: Reserved

Bit 12 = set when the backplane home proximity output bit is set, even if no home operation is occurring.

Bits 13 to 15: Reserved

CURRENT POSITION

These two words report the Current Position based on the number of steps that have been output to the stepper driver. This value may be different from the Encoder Position. A negative Current Position value will be displayed as a negative decimal number in both the MSW and the LSW. If viewed in binary, these words will be in 2s compliment format. When switching from Configuration Mode to Command Mode, the Current Position will be reset to zero.

The $\pm$8,388,607 range of the output parameters does not limit the current position data. The current position instead has a range of 0 to 65,535,999. The LSW word has a range of –999 to 999 and all 16 bits are used in the upper word.   Please note that because the Most Significant Bit is used to indicate the sign, the MSW value will become negative when it changes from 7fffh to 8000h.

ENCODER POSITION

These two words report the position based on the feedback from an encoder attached to the stepper motor. This value may be different from the Current Position. A negative Encoder Position value will be displayed as a negative decimal number in both the MSW and LSW. If viewed in binary, these words will be in 2s compliment format. As with the current position data, the Encoder Position has a range of 0 to 65,535,999. The LSW word has a range of –999 to 999 and all 16 bits are used in the upper word.

CAPTURED DATA

These two words report the data captured when the Capture Input transitions from inactive to active. The value captured will depend on how the 3601 module is configured. If the module's configuration did not include the Quadrature Encoder, the Current Position Data will be captured. If the module's configuration did include the Quadrature Encoder, the Encoder Data will be captured.

A negative Captured Data value will be displayed as a negative decimal number in both the MSW and LSW. If viewed in binary, these words will be in 2s compliment format. As with the both current position data and the encoder position data, the Captured Data has a range of 0 to 65,535,999. The LSW word has a range of –999 to 999 and all 16 bits are used in the upper word.   The Captured Data cannot be reset from the PLC but will be cleared by a homing operation.

The Stopped Bit will be set under the following conditions

1. When a CW or CCW Manual Move operation has been completed.
2. When the Emergency Stop input has been used to stop a move operation.
3. When the Immediate Stop command bit has been used to stop a move operation
4. When either the CW or CCW Limit switches have been reached during any move operation except Homing.
5. After exiting Encoder follower mode.

The Stopped bit will not be set after an Absolute or Relative Move, after a Homing Operation, after a Blend Move, when a move operation is in a Hold State, or when the module is in Encoder follower mode.

The Move Complete Bit will be set under the following conditions

After an Absolute Move, a Relative Move, Encoder Move, or a Blend Move have been successively completed. The Move Complete bit will be reset when the next move operation is initiated. There is no way to manually reset the Move Compete Bit.

The Home Invalid bit will be set under the following conditions

1. Issuing a Home command if the Programmed Speed is less than the starting speed.
2. Issuing a Homing command with the Target Position registers not equal to zero.
3. Issuing a Home Command in a direction that does not have an End Limit Switch configured.
4. If both End Limit Switches are reached during a homing operation. This error will only occur when the motor has reversed direction after encountering the first End Limit switch.
5. If the opposite End Limit Switch is reached during a homing operation. For example, if the CCW Limit Switch is first reached during a CW homing operation. Improper wiring or placement of the limit switch would most likely cause this error.

The Invalid Profile bit will be set under the following conditions

1. If the Programmed Speed is less than the starting speed.
2. If any of the move parameters are outside of their valid ranges.
3. If the defined profile overflows the internal registers of the 3601 module.
4. Setting the number of Blend Move Segments to be less than 2 or greater than 16.
5. If a Blend Move segment does not reach the Programmed Speed. That is, if the distance that it takes to accelerate to the programmed speed exceeds the length of the segment.
6. Two consecutive Blend Move segments with the same Programmed Speed.
7. Programming a Blend Move Profile without a final deceleration value. This parameter is programmed in word 5 of the first Blend Move programming block.
8. If a Manual Move is initiated with data in the Target Position register. (This will be true only on 3601 modules with serial numbers less than 96317.)
9. Changing the speed of a Manual Move whose initial speed was less than or equal to the starting speed.
10. If invalid changes are made to the velocity, acceleration, or deceleration parameters of a manual move that is occurring. This also includes if the lower word is outside of the range of 0 to 999. When detected, motion will immediately stop. The acceleration and deceleration data are only checked when the 3601 module detects a change to the velocity.
11. Starting an Encoder Move if the module has not been configured to use an encoder.
12. If the Registration Move is started with the External Input active.

13. Starting a Registration Move if the number of steps programmed into the target position registers is less than the number of steps required to decelerate and stop the motion. In this case the Registration Move will not start.
14. If the target position registers of a Registration Move are negative.
15. If a value is entered in the target position registers while a standard Manual Move is occurring. Motion will immediately stop.
16. If the value of the target position registers is changed after a Registration Move has been initiated. Motion will immediately stop.
17. Increasing the speed of a Registration Move while it is occurring. Motion will immediately stop. Please note that it is possible to decrease the speed of Registration Move while it is occurring.
18. Changing the acceleration or deceleration parameters while also changing the Programmed Speed during a Registration Move. Motion will immediately stop.

The Position Invalid will be set under the following conditions

1. After a configuration operation has occurred. This will be true even if the position was valid before the configuration operation occurred.
2. After an Immediate Stop command has been issued.
3. If the Emergency Stop input has been activated.
4. If either of the End Limit Switches become active during any move operation except for homing, and if the same end limit is reached during a Manual Move. For example, if the CW Limit Switch is reached during a CW Manual Move.
5. If both End Limit Switches are reached during a homing operation. This error will only occur when the motor has reversed direction after encountering the first End Limit switch.
6. If the opposite End Limit Switch is reached during a homing operation. For example, if the CCW Limit Switch is first reached during a CW homing operation. Improper wiring or placement of the limit switch would most likely cause this error.

The Input Error bit will be set under the following conditions

1. If the Emergency Stop input has been activated.
2. If either of the End Limit Switches become active during any move operation except for homing, and if the same end limit is reached during a Manual Move. For example, if the CW Limit Switch is reached during a CW Manual Move.
3. Performing a Manual Move in the same direction as the active End Limit Switch. For example, starting a CW Manual Move when the CW Limit Switch is active.
4. If both End Limit Switches are reached during a homing operation. This error will only occur when the motor has reversed direction after encountering the first End Limit switch.
5. If the opposite End Limit Switch is reached during a homing operation. For example, if the CCW Limit Switch is first reached during a CW homing operation. Improper wiring or placement of the limit switch would most likely cause this error.

A Command Error will be generated under the following conditions

General Command Errors
1. Configuring the unit while a move operation is occurring. The move will run to completion and then the configuration will be allowed to occur, clearing the command error.
2. If more than one Command bit in output word 0 (MSW) is set.
3. If a move operation is started before the previous move operation is completed. The current move will run to completion.
4. If the Target Position, Programmed Speed, Acceleration, or Deceleration parameters are outside of their valid ranges. This also includes if the LSW is outside of the range of −999 to +999 or if one word of the parameter is negative and the other is not zero and positive.
5. If the programmed speed is less than the starting speed. This applies to Absolute Moves, Relative Moves, Homing operations, and Blend Moves. However, Manual Moves can be run at speeds less than the starting speed.
6. Performing an Absolute Move when the Current Position is not valid.
7. Issuing a Hold Command when there is no Absolute or Relative move in progress. For example, during Manual Moves, Blend Moves, Encoder Moves, Registration Moves, Encoder Follower operations, or Homing Operations.
8. Issuing a Resume command when the channel is not in a Hold state. The current move will run to completion.
9. A Preset Command, including Encoder Preset, that has data in the registers that contain the Programmed Speed, Acceleration, or Deceleration parameters.
10. Issuing a Homing Command with S-Curve Acceleration selected.
11. An encoder preset operation when the module has not been configured to use an encoder.

Command Errors generated by Manual Move Operations
12. Performing a Manual Move with data in the Target Position registers. (This will be true only on 3601 modules with serial numbers less than 96317.)
13. Changing the speed of a Manual Move whose initial speed was less than or equal to the starting speed.
14. Stopping a Manual Move by resetting all eight data words to zero. (This will be true only on 3601 modules with serial numbers less than 96317.)
15. If invalid changes are made to the velocity, acceleration, or deceleration parameters of a manual move that is occurring. When detected, motion will immediately stop. Please note that the acceleration and deceleration are only checked when a change is made to the velocity.

Command Errors generated by Blend Move Operations
16. If a Blend Move operation was initiated before the profile was programmed.
17. If a blend move profile is started with data in the target position, programmed speed, acceleration, or deceleration registers.
18. If a blend move profile is programmed while a blend move operation is in progress. If this occurs, the final segments deceleration will be used to immediately stop the motion.
19. If the hold command is issued while a blend move profile is running. If this occurs, the command error bit will be set while the blend move profile runs to completion. When completed, the command error will be reset.

Command Errors generated by Registration Move Operations
20. If the Minimum Registration Distance is outside of the valid range or is negative.
21. If the Hold Command bit is set while a Registration Move is occurring, but before the Registration Input is detected.
22. If the Registration Move is started with the External Input active.

23. If the number of steps programmed into the target position registers during Registration Move is less than the number of steps required to decelerate and stop the motion. In this case the motion will not start.
24. If the number of steps programmed into the target position registers is negative.
25. If a value is entered in the target position registers while a standard Manual Move is occurring. Motion will immediately stop.
26. If the value of the target position registers is changed after a Registration Move has been initiated. Motion will immediately stop.
27. If the Registration Move speed is increased while motion is occurring. Motion will immediately stop. Please note that it is allowed to decrease the speed while a Registration Move is occurring.
28. Changing the acceleration or deceleration parameters while also changing the Programmed Speed during a Registration Move. Motion will immediately stop.

Command Errors generated by Encoder Follower Operations
29. If the 3601 module is placed in Encoder Follower mode, by setting output word 1 bit 7, without first configuring the module to use an encoder.
30. Trying to place the 3601 module in Encoder Follower mode with motion already occurring. Please note that even though the command error status bit will be set, the original move operation will run to completion.
31. If the multiplier or divisor values are outside of the range of 1 to 32767.
32. If the Programmed Speed registers, output words 4 and 5, are not equal to zero.
33. If the direction of the Encoder Follower motion is changed, by changing which Manual Move command bit is set, without at least one I/O scan where the command word is equal to zero.
34. If any command is issued, including the Hold Command, when the 3601 module is in Encoder Follower mode. That is, if any of the bits in the MSB Command Word other than Manual Move + or Manual Move – are set when the Encoder Follower Bit (output word 1 bit 7) is set.
35. While operating in Encoder Follower Mode, if the Encoder Follower Bit (output word 1 bit 7) is reset while the Manual Move Command bit remains set.
36. Selecting S curve acceleration with Encoder Follower mode.

The Configuration Error bit will be set under the following conditions

1. At power up, before the 3601 module has been configured.
2. If an invalid configuration has been sent to the module.

The Module OK Flag

This bit will be set as long as the module is operating. Only a fatal error will cause this bit to be reset to zero.

Capture Input

If configured, the inactive to active transition of this input will cause either the Current Position or the Current Encoder Data to captured and placed in the input registers. This value will remain until the next inactive to active transition of the input.

External Input

The External Input causes the stepper controller to initiate a controlled stop during a manual move operation. When this input is active, the stepper motor will decelerate to the starting speed, and stop, while keeping track of the current position. During an absolute or relative move, the External Input will cause the module to make a controlled stop to a hold state.

If the External Input is active when a move operation is initiated, the 3601 module will generate one step in the specified direction and then stop.

A Command Error will be generated if the external input is active when a Registration Move operation is started.

The External Input has no affect on Encoder Follower operations.

Emergency Stop Input

The Emergency Stop Input causes the current move operation to stop without any deceleration. The pulse signal is simply removed. The Position Invalid Input Bit will be set if the channel was moving when this input became active. The channel will have to be Preset or Homed again before an Absolute Move operation can be performed. However, it will be possible to perform a Relative or a Manual Move after the Emergency Stop Input has been used.

Optical Encoder

The 3601 module uses X4 decoding on the encoder signals. Only a 5V differential encoder can be directly attached to the module. Encoders at other voltage levels can be connected to the module if current limiting resistors are used. A move profile does not have to be in progress in order for the unit to count encoder pulses.

Manual Revision History

Revision 0.0 was released on 1/13/03 and was the initial release of the specifications.

Revision 0.1 was released on 2/19/03. The function of the capture input was changed to capture the current position data if the module is not configured to use a Quadrature Encoder. Also, it is no longer considered an invalid configuration to use the Capture Input without the Quadrature Encoder. These changes are incorporated in the version 2.1 firmware.

Revision 1.0 was released on 3/24/03. The ability to use the 3601 module in a MicroLogix system was added to the module. This change is incorporated into version 2.2 of the firmware.

Revision 1.1 was released on 7/22/03. The header was changed to read both CompactLogix and MicroLogix. Additional information was added on Holding a move and on the Stopped and Move Complete input bits.

Revision 1.2 was released on 8/14/03.

1. Details on the Stopped Bit were added.
2. Details on the Move Complete bit were added.
3. Added details that a Home Invalid and Invalid Profile error will cause the Axis Error LED to flash red.

    4. Changed the I/O common terminal to Module Common and added some notes on wiring.

Version 2.0 was released on 4/29/05. This replaced specification version 1.2. The following changes were made.

- A table of contents was added.
- The wiring information was changed to make the specifications compatible with the rev B PC board. The rev A PC board had the encoder inputs reversed and would not work as shown with single ended encoders. Differential encoders are unaffected.
- The specifications and pin out were moved to the front of the specifications.
- A section on calculating move profiles was added.
- A section on registration moves, new with firmware version 3.1, was added.
- Details were added to the functions of the status bits.

Version 2.1 was released on 5/11/05. This version corrected a mistake in the distance to accelerate move profile formula (it should be Ta * (Vo + Vf)/2) and the method used to display and enter negative numbers was added both to the module overview and to the output programming information.

Version 3.0 was released on 5/1/06. This version added the encoder follower functions to the specifications, added diagrams that showed the difference between Step/Direction and CW/CCW outputs, and divided the causes of a command error into sections. To shorten the specifications, the sample program was removed and references to the online sample programs were added at the beginning of the input and output data sections.

Version 3.1 was released on 3/8/2013. The following changes were made.

- Added information for adding the 3601 module to the I/O using the profile available in RSLogix 5000 V20 or higher.
- Added environmental information to the specifications.
- Added discrete input wiring information.
- Added details on using the backplane home proximity bit

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