
Module Overview

The 3501-HSTP1 module is a one-axis stepper controller that occupies one slot in a SLC 500 rack and is a direct plug in replacement for the Rockwell Automation 1746-HSTP1 module.

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 for homing, over travel, and emergency stop. A 5V differential incremental encoder can be attached to the unit to provide feedback information.

The 3501-HSTP1 module uses 8 input and 8 output registers to communicate with the PLC. Status bits, the Current Position, and Encoder Count 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.

Some of the data used by the 3501-HSTP1 can exceed 32767, the value that can be contained in one 16 bit register. Because of this, these parameters are divided into two words, the Most Significant Word (MSW) and the Least Significant Word (LSW). The MSW has the 1000s places and the LSW has the 1s, 10s and 100s places. Negative values are handled using a sign magnitude format where the Most Significant Bit in the MSW is set to indicate a negative value. For example:

| Value | MSW (decimal) | MSW (hex) | LSW (decimal) | LSW (hex) |
|--------------|--------------------------|----------------------|--------------------------|----------------------|
| -12,345 | -32,756 | 16#800C | 345 | 16#0159 |
| 12,000 | 12 | 16#000C | 0 | 16#0000 |
| -12,000 | -32,756 | 16#800C | 0 | 16#0000 |
| 345 | 0 | 16#0000 | 345 | 16#0159 |
| -345 | -32768 | 16#8000 | 345 | 16#0159 |

Because the 3501-HSTP1 module does not use a non-volatile memory, it must be configured at every power up.

Sample programs for the 3501-HSTP1 are available from the following page of our website.

<https://www.amci.com/industrial-automation-support/sample-programs/>

General Information

Important User Information

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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.

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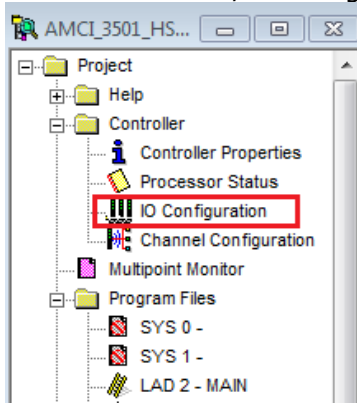
Chapter 1: Installing the 3501-HSTP1 module

WARNING Disconnect power before installing or remove the 3501-HSTP1 module.

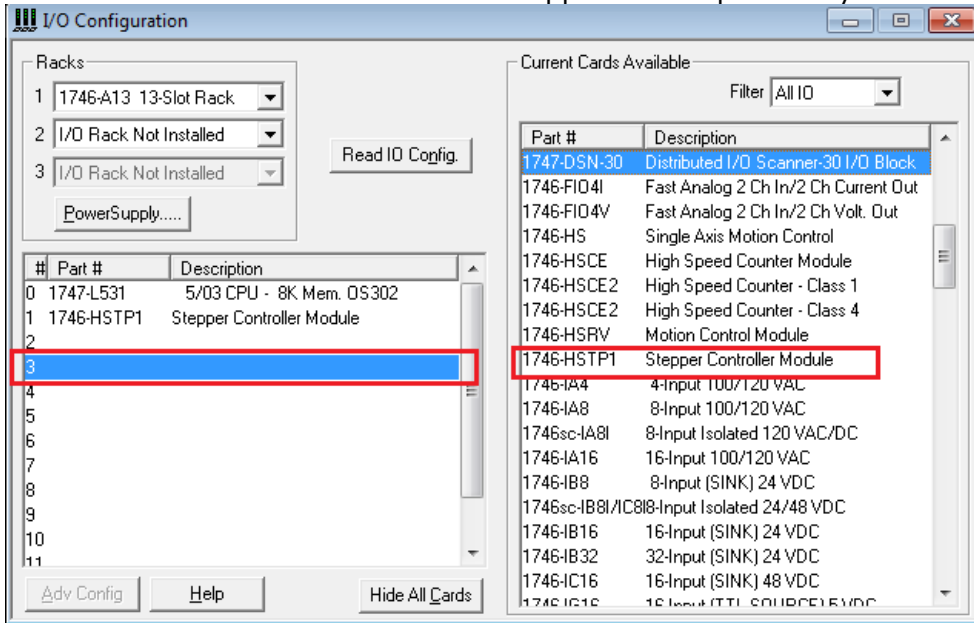
1. Verify that your system’s power supply has adequate reserve current capacity. The 3501-HSTP1 module requires 200mA at +5Vdc.
2. Align the module with the grooves in the top and bottom of the SLC rack system and slide the module backwards until the tabs on the plastic housing lock the module in place.

SLC 500 Rack Configuration

1. Double Click on I/O Configuration in the Project Tree.



2. Select the desired unused slot and double click on the 1764-HSTP1 module from the list of available modules. The module will appear in the previously unused slot.



3. Input Data (data from the 3501-HSTP1 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 3501-HSTP1 module) will be written to registers O:X.0 to O:X.7, where X is the slot number.

Module Specifications

- Backplane Current Draw: 200mA @5Vdc
- External User Power: 90mA @ 24Vdc

Stepper Outputs

Output Voltage: +5Vdc differential (3.5Vdc to 4Vdc peak typical)
Maximum Output Current: 20mA
Maximum Output Frequency: 250kHz

Encoder Inputs

5V differential encoder only
A, B, and Z Maximum Input Current: 10mA per channel @5Vdc

The A and B signals must both be connected to the 3501-HSTP1 module to have the encoder data increment or decrement.

Discrete Inputs

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

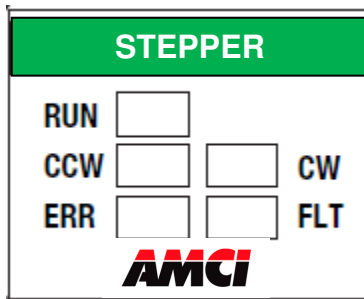
Input Current: 15mA @ 24Vdc
Response Time (On and Off): 5 μ s
Scanning Time: The input must be on for 250ms to be detected by the module.
Active State: The discrete inputs can be configured to be Active High (for use with a normally open contact) or Active Low (for use with a normally closed contact).

Input Functions: External Input, Home Input, Home Proximity Input, Emergency Stop, CW Limit Switch, and CCW Limit Switch. (The External Input only affects Jog Moves. The Home and Home Proximity Inputs 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



RUN

Off: Module not powered or not operating correctly
Solid Green: Module Operating Correctly

CW

Off: Motion not occurring in the CW direction
Solid Green: Motion occurring in the CW direction

CCW

Off: Motion not occurring in the CCW direction
Solid Green: Motion occurring in the CCW direction

ERR

OFF: No Command Errors exist
Solid Red: An Error occurred during Command operations

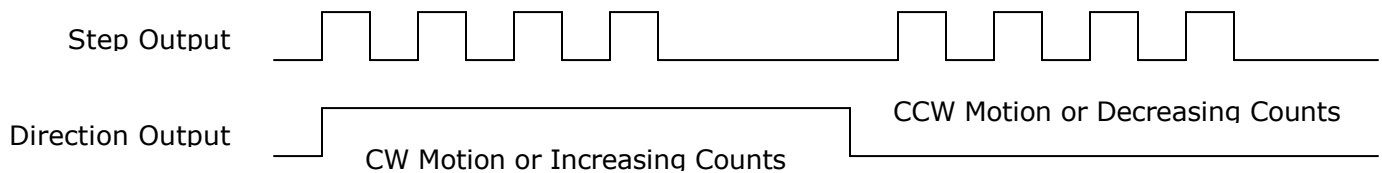
FLT

OFF: No Configuration Error exists
Solid Red: The 3501-HSTP1 is either not configured or has been sent invalid Configuration Data.

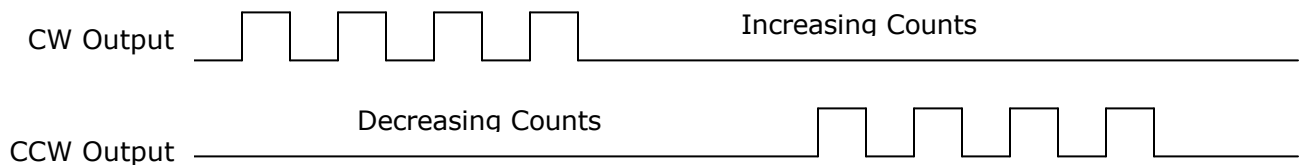
Output Signals

The 3501-HSTP1 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 3501-HSTP1 module to match the input type of your driver. The two types of signals are illustrated below.

Step and Direction Output



CW and CCW Step Outputs



Connector Pin Out

The input connector is included with the 3501-HSTP1 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.

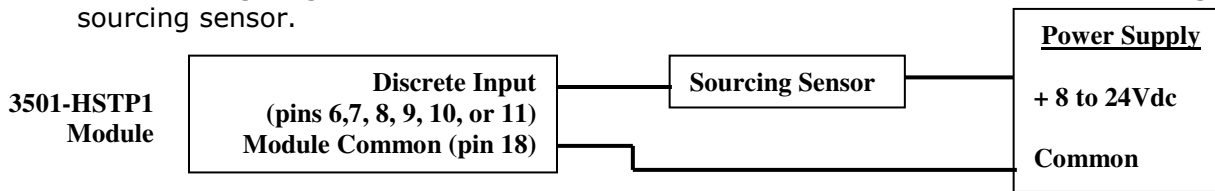
| | | | |
|---------------------------|----|----|---------------------------|
| 7 to 24Vdc User Power | 1 | 2 | +Step or +CW |
| -Step or -CW output | 3 | 4 | +Direction or +CCW output |
| -Direction or -CCW output | 5 | 6 | External Input |
| Home Input | 7 | 8 | Home Proximity Input |
| CW Limit Switch | 9 | 10 | CCW Limit Switch |
| Emergency Stop Input | 11 | 12 | +A Encoder Input |
| -A Encoder Input | 13 | 14 | +B Encoder Input |
| -B Encoder Input | 15 | 16 | +Z Encoder Input |
| -Z Encoder Input | 17 | 18 | Module Common |

Wiring Notes:

- The 3501-HSTP1 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.
- 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 18) must be connected to the common of the 7 to 24Vdc User Power Supply. The common of the supply that powers the discrete inputs must also be connected here. A Stepper Driver with Single Ended Step and Direction inputs can also be referenced here.

Discrete Inputs Wiring

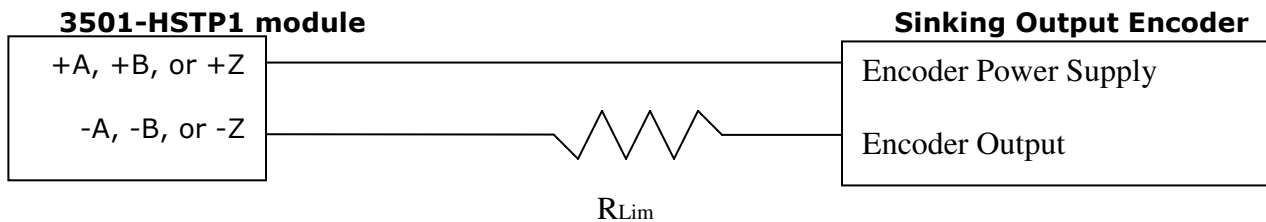
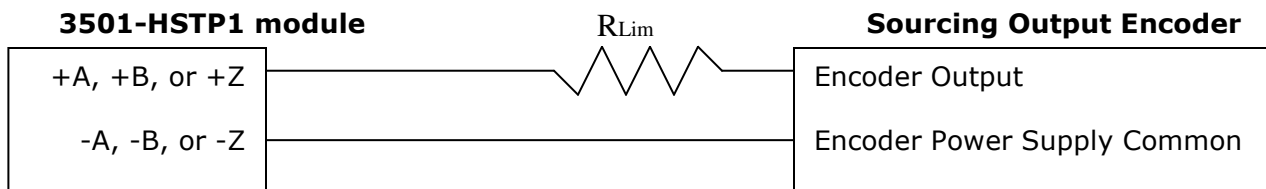
The following diagram shows how to wire the 3501-HSTP1 module's discrete sinking inputs to a sourcing sensor.



Single Ended Encoder Wiring

The 3501-HSTP1 module is designed to work with +5Vdc differential encoders. Use the following table and diagrams to attach single ended encoders to the 3501-HSTP1 module. A current limiting resistor R_{Lim} must be installed for encoders that do not operate at 5Vdc.

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



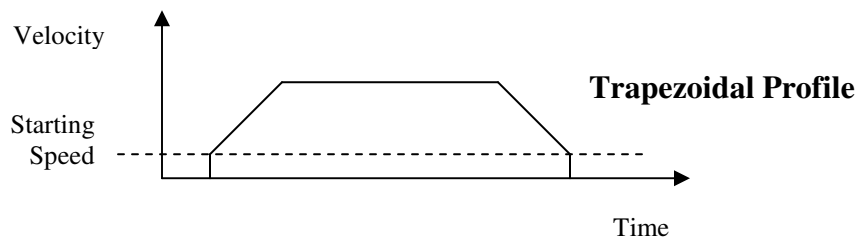
Diagnostic Feedback Wiring

| Pin Numbers | Signal Names |
|-------------|------------------|
| 2 to 12 | +Step to -A |
| 3 to 13 | -Step to +A |
| 4 to 14 | +Direction to -B |
| 5 to 15 | -Direction to +B |

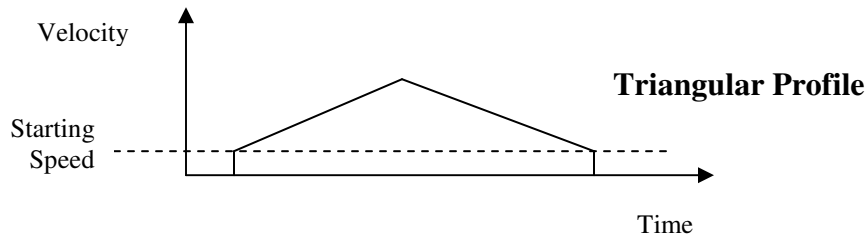
Chapter 2: Calculating Move Profiles

Before starting a move operation, the 3501-HSTP1 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.



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.

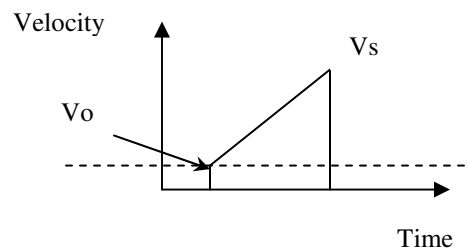


Regardless of the type of Velocity Profile that is being run, the following equations can be used to determine both the time to accelerate and the number of steps needed to accelerate. These formulas can also be used to calculate the time and distance to decelerate.

$$T_a = (V_s - V_o) / a$$

$$D_a = T_a * (V_o + V_s) / 2$$

- V_o = Starting Speed (steps/second)
- V_s = Programmed Speed (steps/second)
- T_a = Time to accelerate (seconds)
- D_a = Distance to accelerate (steps)
- a = Acceleration rate (steps/second/second)



The acceleration rate entered in these equations must have units of steps/second/second, not the steps/ms/second used by the 3501-HSTP1 module. See the Calculation Notes below for a complete explanation.

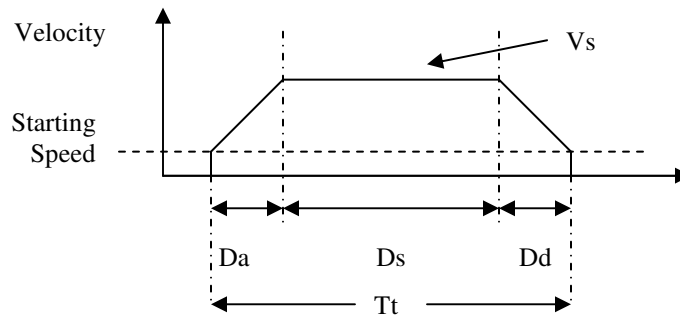
Calculation Notes

1. The acceleration and deceleration values sent to the 3501-HSTP1 module as part of the move profile have units of steps/ms/sec.

If you are using the above formulas to calculate T_a (the time to accelerate), multiply the acceleration value sent to the 3501-HSTP1 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 3501-HSTP1 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 3501-HSTP1 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 3501-HSTP1 module will run a *Trapezoidal Velocity Profile*.



$$D_s = (\text{Total Number of Steps}) - (D_a + D_d)$$

$$T_t = T_a + T_d + D_s/V_s$$

D_a = Distance to Accelerate (steps)

D_s = Distance at the programmed speed (steps)

D_d = Distance to decelerate (steps)

V_s = Programmed Speed (steps/sec)

T_t = Total Profile Time (seconds)

Starting Speed

The starting speed has a range of 1 to 250,000 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 3501-HSTP1 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 Jog Move operation.

If the External Input is active when a jog move operation is initiated, the 3501-HSTP1 module will generate one step in the specified direction and then stop.

5. If a Home Limit Switch will be used and its input active state.
6. If a Home Proximity Limit Switch will be used and its 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 three Homing possibilities.

1. Home Limit Switch Only
2. Home Limit Switch with Home Proximity Limit Switch.
3. Marker Pulse Home with the Home Proximity Limit Switch.

Note 1: When configured to use a Home Proximity Input, the 3501-HSTP1 module will ignore any other home inputs until the proximity input is detected.

Note 2: The Marker Pulse option also requires the presence of the Quadrature Encoder.

11. The Starting Speed. The starting speed is the pulse frequency at which every move begins and ends. 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 3501-HSTP1 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 250,000 |
| 3 | Starting Speed LSW | | |
| 4 | 0 | | |
| 5 | 0 | | |
| 6 | 0 | | |
| 7 | 0 | | |

- Note 1:** The module will power up in Configuration Mode showing a Configuration Error. The Configuration Error bit will remain set until valid configuration data has been written to the module.
- Note 2:** If Configuration Mode is entered while a move is occurring, 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, then the MSW would be 12 and the LSW would be 345.

Configuration Bits MSW

- Bit 0: set when a CW Limit Switch will be used
- Bit 1: set when a CCW Limit Switch will be used
- Bit 2: set when the Emergency Stop Input will be used
- Bit 3: set when an External Input is used.
- Bit 4: set when the Home Limit Switch Input will be used.
- Bit 5: set when the Home Proximity Input will be used
- Bits 6 and 7 reserved, must be zero
- 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, must be zero
- Bit 12: "0" for limit switch home operations, "1" for marker pulse home operations
- Bits 13 and 14: reserved, must be zero
- Bit 15: "1" for configuration mode operations, "0" for command mode operations

Configuration Bits LSW

- Bit 0: determines the active level of the CW Limit Switch input
- Bit 1: determines the active level of the CCW Limit Switch input
- Bit 2: determines the active level of the Emergency Stop input
- Bit 3: determines the active level of the External input
- Bit 4: determines the active level of the Home Limit Switch input
- Bit 5: determines the active level of the Home Proximity input
- Bits 6 to 15: Reserved, must be zero

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 250,000 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 3501-HSTP1 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. Using a Marker Pulse Home without the Home Proximity Input.
6. A configuration file that specifies the Home Proximity Input without either the Home Input or the Marker Home.
7. Diagnostic Feedback with CW and CCW pulse outputs.
8. A starting speed outside the range of 1 to 250,000 steps /sec.
9. If the lower word of the starting speed is outside of the range of 0 to 999.
10. Setting any of the unused bits in the configuration words.
11. Selecting Marker Pulse home with both the Home Input and the Home Proximity Input.
12. Setting any of the unused words to a value other than zero.

The 3501-HSTP1 module has to be configured before starting any operations. When the Configuration Mode status bit 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 status bit 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 3501-HSTP1 module to the PLC)

While in configuration mode, the input registers will mirror the configuration data that was sent to the 3501-HSTP1 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 |

Note: Input Word 0, bits 13 to 15 are not mirrored. These three bits always function as status bits, regardless of whether the 3501-HSTP1 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 both the Current and Encoder Positions will be zero.

Absolute & Relative Moves

The current position must to be valid (input word 0 bit 10 must be reset) 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 3501-HSTP1, 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, then 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, then CW motion will occur. If the Target Position < Current Position, then 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, then 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

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 effect, 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 3501-HSTP1 module.

- A Command Error will be generated if all of the other command bits are not reset when the Hold Command is issued.
- The 3501-HSTP1 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 3501-HSTP1 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. A Hold Move command issued during a home operation will be ignored.
- Blend Moves cannot be held. The 3501-HSTP1 will ignore a Hold Move command that is issued while a Blend Profile is running.
- Jog Moves cannot be held. A Hold Move command is issued during a jog operation will be ignored.

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 bit will be reset. 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 or Blend Move operation can be performed. However, it will be possible to perform a Relative Move or a Jog 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 three homing options available. They are,

- Home Limit Switch Only
- Home Limit Switch with a Home Proximity Input
- Marker Pulse Home with Home Proximity Input

The function of the Proximity Input is exactly as it seems. When Proximity Input is used, the 3501-HSTP1 module will ignore any transitions of the Home Input or the Marker Pulse until it detects the proper transition on the Proximity Input.

When the homing operation is complete, the 3501-HSTP1 will set the At Home input bit, and then reset both the current position and the encoder position to zero.

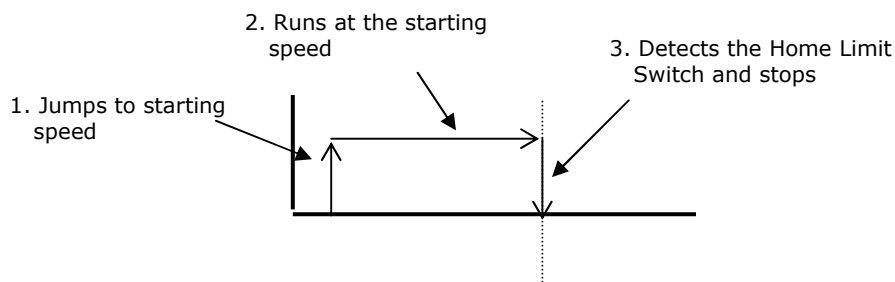
When issuing a Find Home command, the Target Position registers must be equal to zero, the Programmed Speed must be greater than or equal to the Starting Speed, and the Acceleration and Deceleration parameters must be present and valid.

The Find Home commands require that at least one End Limit Switch, either CW or CCW, be configured. The 3501-HSTP1 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 is attempted, the COMMAND ERROR Input bit will be set.

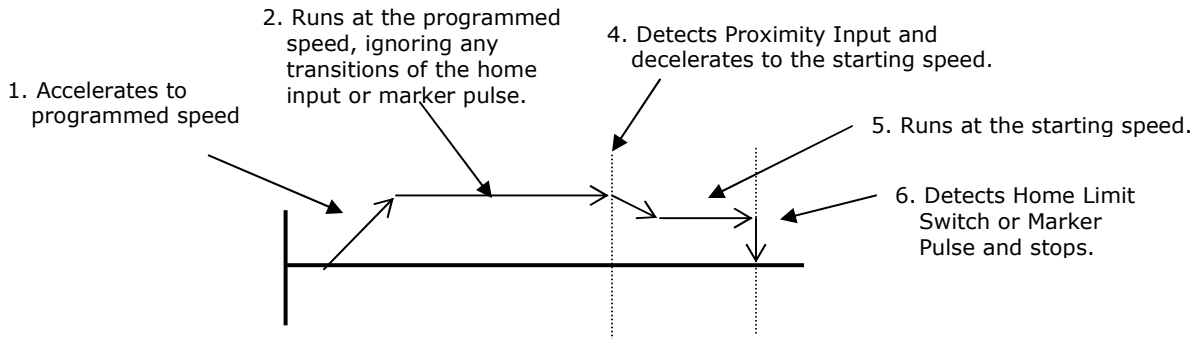
If, during a Home operation, either of the End Limit Switch endpoints are reached, the module will stop outputting steps (essentially an emergency stop), reverse direction, and start searching for the appropriate homing signal again. It is important not to have the velocity set too high during a homing 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.

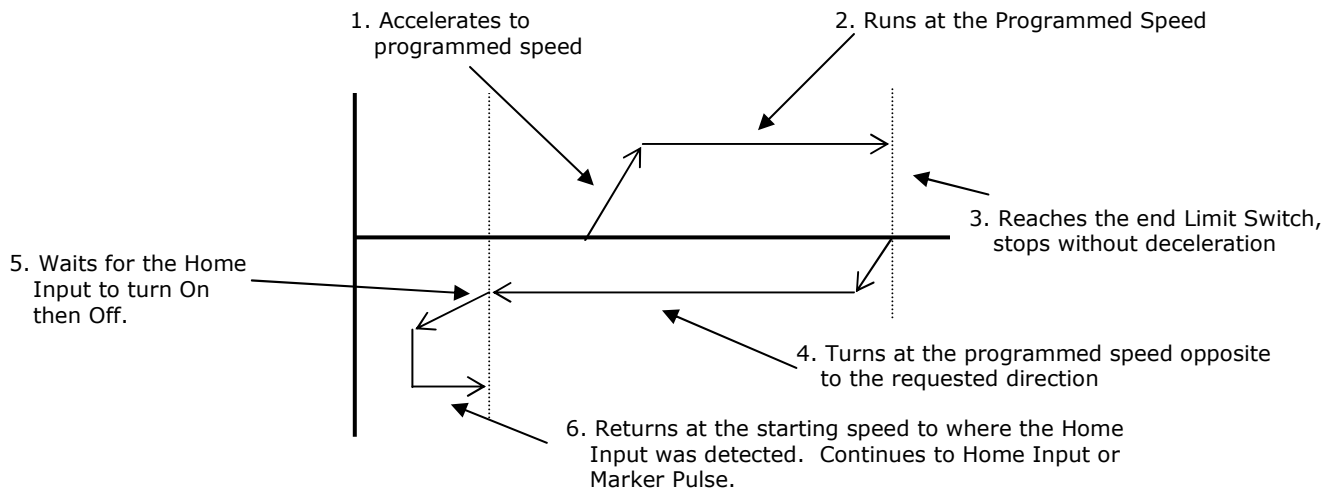
Home Limit Switch Only



Home Proximity Input with Home Limit Switch or Marker Pulse

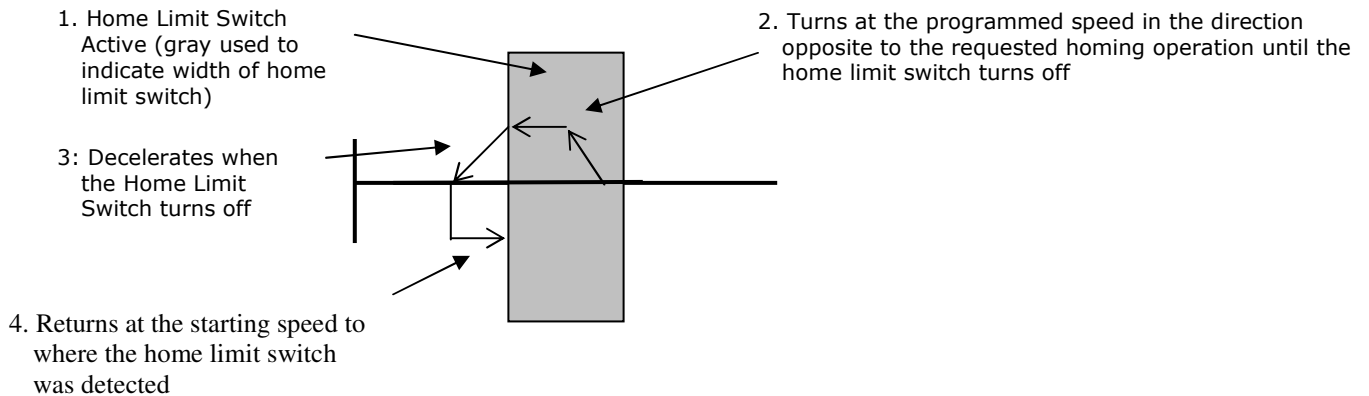


Reaching an End Limit Switch During a Homing Operation

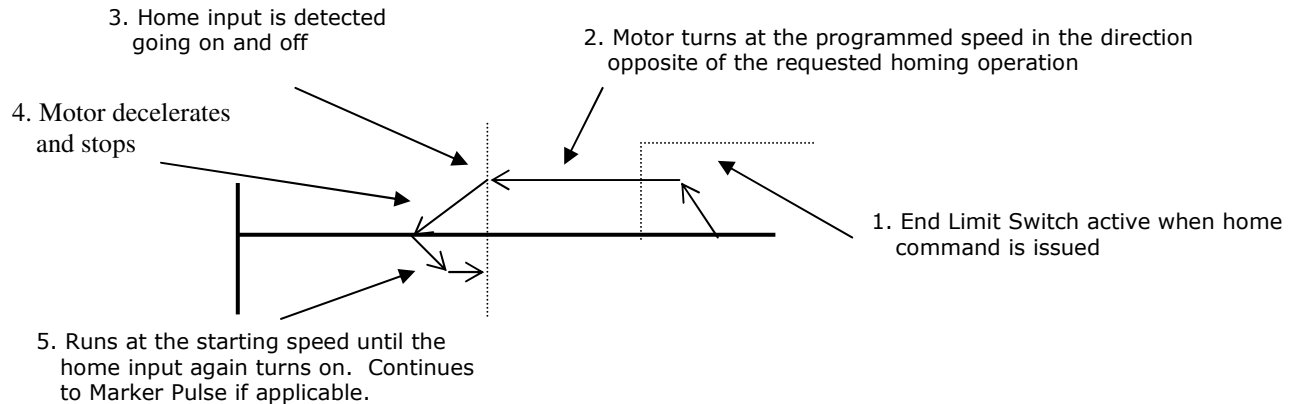


Note: The Home Input shown above can be either the Home Limit Switch or the Home Proximity Input.

Home Limit Switch or Home Proximity Active when the Home Command is issued



End Limit Switch Active when the Home Command is issued



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

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, then the unit will home normally, as if the end limit switch was not active.

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

This command performs the Jog 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 must be zero during all Jog Move operations.

The speed of the jog command cannot be changed while motion is occurring.

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 Jog 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 CW or CCW Limit Switch is reached

When stopping a Jog Move, only 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 Jog 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.

An additional feature of the Jog Move parameter is the ability to do a One Shot Jog Move. With the programmed speed set to zero, a 0 → 1 transition of the Jog Move bit will cause the stepper controller to output 1 pulse in the specified direction. Please note that the CW Motion and CCW Motion status bits will not be set during, and the Stopped bit will not be set at the end of a One Shot Jog Mode operation.

The One Shot Jog is the only command that can be used to jog off of an active CW or CCW 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 must be zero 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 3501-HSTP1 module must be configured to use an encoder, and the programmed speed, acceleration, and deceleration parameters must be zero when this command is sent to the module.

Reset Errors

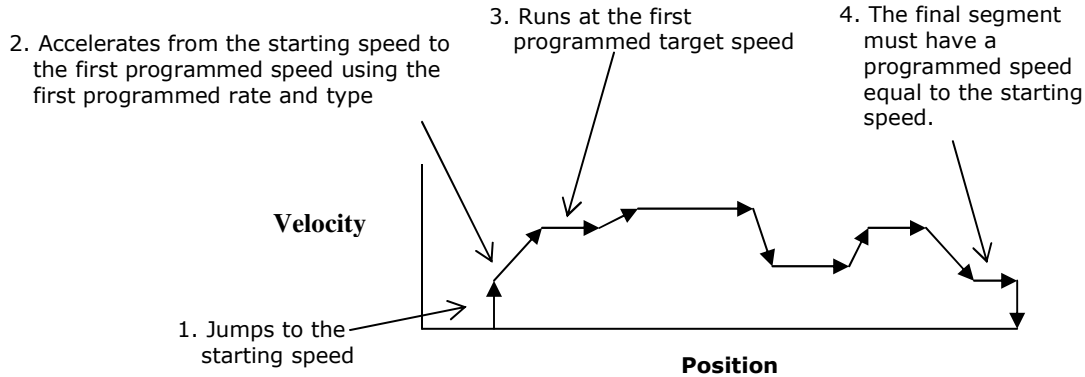
This command clears all nonfatal errors detected by the stepper controller. A nonfatal error is one that can be recovered from. For example, trying to perform an Absolute Move when the position is not valid is a nonfatal error. The Lower Command Word must be zero when the Reset Errors command is issued. 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 or COP, instructions be used to send commands to the 3501-HSTP1 module.
2. 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 jog move operation, the module will treat the input as an emergency stop, meaning that the motor will stop without deceleration and the position will become invalid.
5. It is possible to home the 3501-HSTP1 module off of an end limit switch.
6. Sample Programs are available from the following page of our website;
<https://www.amci.com/industrial-automation-support/sample-programs/>

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. Absolute Segment end position
2. Target speed
3. Acceleration Rate
4. Deceleration Rate

The minimum amount of information necessary to define a new move segment is the Absolute Target Position and the Target Speed. The Acceleration and Deceleration rate do not have to change from one segment to the next. A Command 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 3501-HSTP1. 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 Absolute Moves (segments), so the position must 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 must have a programmed speed equal to the starting speed that was programmed in the configuration data.

It is not possible to program a direction reversal in the blend move profile.

Because the 3501-HSTP1 module stores the data for the Blend Move Profile in its memory, the programmed profile can be run more than once. However, you must always start the blend move from the same absolute position at which the blend move profile was programmed.

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.

Diagnostic Feedback wiring can only be used if the 3501-HSTP1 module has been configured to output Step and Direction signals.

The maximum input frequency that the module can accurately measure in Diagnostic Feedback mode is 250kHz.

Diagnostic Feedback Wiring

| Pin Numbers | Signal Names |
|--------------------|---------------------|
| 2 to 12 | +Step to -A |
| 3 to 13 | -Step to +A |
| 4 to 14 | +Direction to -B |
| 5 to 15 | -Direction to +B |

Chapter 5: Command Mode Output Data

(Eight 16 bit words sent from the PLC to the 3501-HSTP1 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.

These output words are defined as O:X.0 to O:X.7, where "X" indicates the slot number. The following table shows the function of the output registers

| 16 bit Output Word | Function | Units | Range |
|--------------------|----------------------|--------------|---------------------------|
| 0 | Command MSW | | See description below |
| 1 | Reserved | | Must be zero |
| 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 250,000 |
| 5 | Programmed Speed LSW | | |
| 6 | Acceleration | Steps/ms/sec | 1 to 2000 |
| 7 | Deceleration | Steps/ms/sec | 1 to 2000 |

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 JOG MOVE +/(CW) operation
- Bit 8 = set to perform a JOG 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 perform a RESET ERRORS operation
- Bit 11 = set to PROGRAM A BLEND MOVE PROFILE
- Bit 12 = set to READ BLEND DATA
- Bit 13 = set to RUN BLEND MOVE PROFILE
- Bit 14 = set to PRESET optical encoder
- Bit 15 = MODE FLAG: "1" for Configuration Mode "0" for Command Mode

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 or COP be used to send commands to the 3501-HSTP1 module.
2. A move operation should only be started if the Move Complete, Stopped, or Hold status bits are set.
3. Negative values are transferred using a sign magnitude format. A negative Target Position value will be programmed by setting the Most Significant Bit in the Most Significant Target Position Word.

| Value | MSW (decimal) | MSW (hex) | LSW (decimal) | LSW (hex) |
|--------------|--------------------------|----------------------|--------------------------|----------------------|
| -12,345 | -32,756 | 16#800C | 345 | 16#0159 |
| 12,000 | 12 | 16#000C | 0 | 16#0000 |
| -12,000 | -32,756 | 16#800C | 0 | 16#0000 |
| 345 | 0 | 16#0000 | 345 | 16#0159 |
| -345 | -32768 | 16#8000 | 345 | 16#0159 |

4. The Position parameter has a range of $-8,388,608 \leq \text{Target Position} \leq 8,388,607$.
5. The LSW of the Target Position has a range of 0 to 999.
6. The Programmed Speed has a range of $\text{Starting Speed} \leq \text{Programmed Speed} \leq 250,000$ 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 $1 \leq \text{acceleration / deceleration} \leq 2,000$ 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 are available from the following page of our website;
<http://www.amci.com/sampleprograms.asp>

Blend Move Programming

A Blend Move consists of two to sixteen segments made up of an absolute target position, a programmed Velocity, Acceleration, and Deceleration values. The blend move operation will be run each time bit 13 in the Command Word MSW transitions from 0 to 1.

1. Bits 11 and 12 of the MSW Command Word control the transfer of the blend move segments from the PLC to the 3501-HSTP1. The first step is to set bit 11, the Program a Blend Move Profile command bit.
2. The 3501-HSTP1 module responds by setting Input Word 0 bits 8, the blend move mode bit, and bit 9, the send the next blend move segment bit.
3. When the PLC detects that the send next blend move mode bit, I:X.0/9, is set, it sends the first blend move segment, which has a value of 6144, bits 11 and 12 set, in output word 0, the absolute target position, the programmed speed, acceleration, and deceleration.
4. The module checks the segment's data. If the data is not correct, the module sets the command error bit, I:X.0/12. If the data is correct, the module resets the send next blend move data bit, I:X.0/9.
5. The resetting of send next blend move segment causes the PLC program to reset the send the next blend move bit, O:X.0/12, in the command word.
6. The module responds by setting the send the next blend move segment bit I:X.0/9.
7. The module sends the next blend move segment data.
8. The above process repeats from 4 until all of the blend segments have been programmed.

The Programmed Velocity of the final programmed segment must be equal to the starting speed that was programmed in words 2 and 3 of the configuration data

9. After the final segment has been programmed, the PLC resets both 11 and 12 of the MSW command word. This causes the 3501-HSTP1 module to exit blend move mode.

The following tables show the layout of the blocks of data used to program a blend move profile.

BLEND MOVE DATA – FIRST PROGRAMMING BLOCK

| Word | Function |
|------|----------|
| 0 | 2048 |
| 1 | 0 |
| 2 | 0 |
| 3 | 0 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |

BLEND MOVE DATA – PROGRAMMING BLOCKS 2...17

| Word | Function |
|------|------------------------------|
| 0 | 6144 (bits 11 and 12 set) |
| 1 | Must be zero |
| 2 | Absolute Target Position MSW |
| 3 | Absolute Target Position LSW |
| 4 | Target Speed MSW |
| 5 | Target Speed LSW |
| 6 | Acceleration |
| 7 | Deceleration |

BLEND MOVE DATA – PROGRAMMING BLOCKS, Final Segment

| Word | Function |
|------|------------------------------|
| 0 | 6144 (bits 11 and 12 set) |
| 1 | Must be zero |
| 2 | Absolute Target Position MSW |
| 3 | Absolute Target Position LSW |
| 4 | Starting Speed MSW |
| 5 | Starting Speed LSW |
| 6 | Acceleration |
| 7 | Deceleration |

Blend Profile Programming Restrictions

- The target position of the final segment must be less than 8,388,607.
- Each segment must contain enough steps for the programmed speed to be reached. That is, there must be enough steps to complete the acceleration or deceleration portions of the move.
- The LSW of the target position has a range of 0 to 999.
- You cannot reverse direction in a blend move profile.

Chapter 6: Command Mode Input Data**(Eight 16 bit words sent from the 3501-HSTP1 module to the PLC)**

Sample Programs are available from the following page of our website;
<https://www.amci.com/industrial-automation-support/sample-programs/>

The 3501-HSTP1 module uses eight 16 bit words to reports its data to the PLC. These input words are defined as I:X.0 to I:X.7, where "X" indicates the slot number. The following table shows the function of these eight words.

| 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 or Diagnostic Feedback Data MSW |
| 5 | Current Encoder or Diagnostic Feedback Data LSW |
| 6 | Always zero |
| 7 | Always zero |

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. The AT HOME bit will not be set if you use some other method to return to the home position.

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. This bit will be reset at the beginning of the next move.

Bit 8 = set when the module is in BLEND MOVE MODE

Bit 9 = send the NEXT BLEND MOVE SEGMENT bit

Bit 10 = set when POSITION INVALID. You cannot perform absolute or blend moves while the position is invalid.

Bit 11 = set when there is an INPUT ERROR. (This bit will be reset by a RESET ERRORS command. Move operations will still occur when this bit is set.)

Bit 12 = set when there is a COMMAND ERROR. (This bit will be reset by a RESET ERRORS command. This bit must be reset before another command 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 CW LIMIT SWITCH is active

Bit 1 = set when the CCW LIMIT SWITCH input is active

Bit 2 = set when the EMERGENCY STOP input is active

Bit 3 = set when the EXTERNAL INPUT is active

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

Bit 5 = set when the HOME PROXIMITY LIMIT SWITCH input is active

Bits 6 & 7 Reserved

Bit 8 = set when there is a HOME INVALID error. This bit will be set if a home operation was not able to run to completion.

Bits 9 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. The Current Position value is negative when bit 15, the most significant bit, is set in the Most Significant word. 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 $\pm 65,535,999$. The LSW word has a range of 0 999 and all 16 bits are used in the upper word. Please note that because the PLC uses the Most Significant bit to indicate the sign, the MSW value will become negative when, while the counts are increasing, it changes from 16#7fff to 16#8000.

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. The Encoder Position value is negative when bit 15, the most significant bit, is set in the Most Significant word. When switching from Configuration Mode to Command Mode, the Encoder Position will be reset to zero.

The encoder position has a range of 0 to $\pm 65,535,999$. The LSW word has a range of 0 999 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, while the encoder counts are increasing, it changes from 16#7fff to 16#8000.

The Stopped Bit will be set under the following conditions

1. When a CW or CCW Jog 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.

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

The Move Complete Bit will be set under the following conditions

After an Absolute Move, a Relative 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 Complete Bit.

The Home Invalid bit will be set under the following conditions

1. 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.
2. 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 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 the CW or CCW Limit Switches become active during any move operation
5. If both CW or CCW 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.
3. 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.
4. 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. If more than one Command bit in output word 0 (MSW) is set.
2. 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 0 to 999.
3. If the programmed speed is less than the starting speed. This applies to Absolute Moves, Relative Moves, Jog Moves, Homing operations, and Blend Moves.
4. Performing an Absolute Move when the Current Position is not valid.
5. Issuing a Resume command when the channel is not in a Hold state. The current move will run to completion before the Command Error bit is set.

Command Errors generated by Blend Move Operations

6. If a Blend Move operation was initiated before the profile was programmed.
7. If a Blend Move is started from a position that is different from where it was programmed.
8. If a Blend Move is started when the position is invalid.
9. If a blend move profile is programmed while a blend move operation is in progress. If this occurs, the blend move will run to completion before the Command Error bit is set.

The Configuration Error bit will be set under the following conditions

1. At power up, before the 3501-HSTP1 module has been configured.
2. If an invalid configuration has been sent to the module.

The Module OK Bit

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.

External Input

The External Input causes the stepper controller to initiate a controlled stop during a jog 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.

If the External Input is active when a jog move operation is initiated, the 3501-HSTP1 module will generate one step in the specified direction and then stop.

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 before an Absolute or Blend Move operation can be performed. However, it will be possible to perform a Relative Move or a Jog Move after the Emergency Stop Input has been used.

Optical Encoder

The 3501-HSTP1 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 1.0 was released on 1/25/2017 and was the initial release of the manual.

File: 3501-HSTP1_manual.doc
Date: 1/25/2017