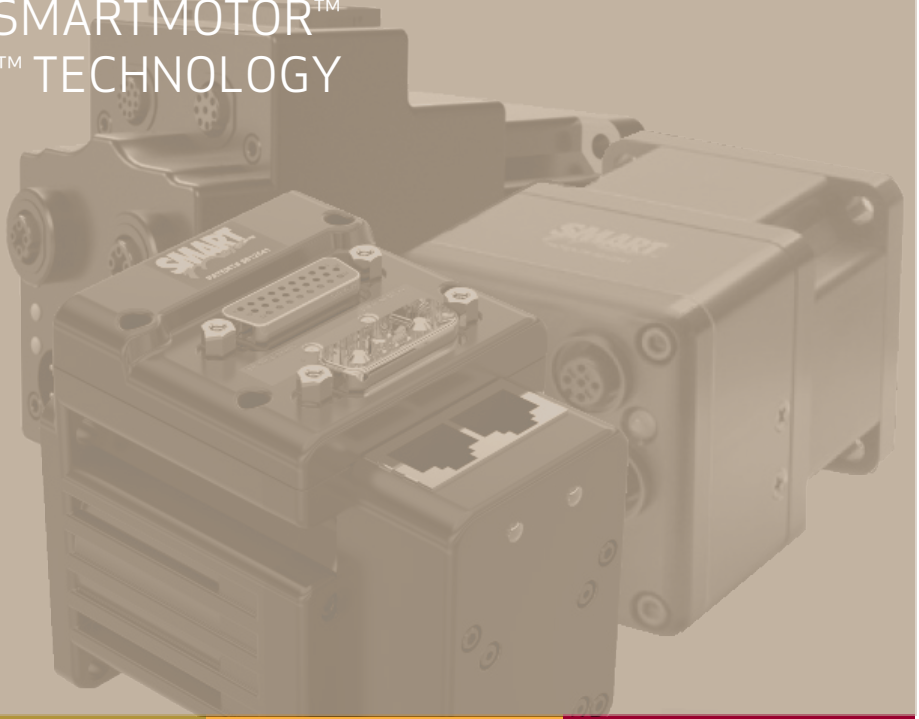


APPLICATION NOTE FOR

FULLY INTEGRATED SERVO MOTORS

HOMING PROCEDURES AND METHODS
FOR CLASS 5 AND 6 SMARTMOTOR™
WITH COMBITRONIC™ TECHNOLOGY



Revised: 03/30/2022

DESCRIBES HOMING PROCEDURES AND
METHODS FOR USE WITH SMARTMOTOR™
SERVOS

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Moog Animatics SmartMotor™ Homing Procedures and Methods Application Note Application Note,
Revised: 03/30/2022.

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Please let us know if you find any errors or omissions in this manual so that we can improve it for future readers. Such notifications should contain the words "SmartMotor™ Homing Procedures and Methods Application Note Application Note" in the subject line and be sent by e-mail to: animatics_marcom@moog.com. Thank you in advance for your contribution.

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Introduction

This chapter provides information on the purpose of this document. It also provides information on safety, and where to find related documents and additional resources.

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Purpose

This document describes the Homing procedures and methods available for the Moog Animatics SmartMotor™ servos. The purpose is to explain the basic concepts that system builders and programmers should keep in mind when integrating a SmartMotor into the design. Because system design is quite complex, this document focuses on only those items that directly affect the integration and performance of the SmartMotor.

This document applies to Class 5 and Class 6 SmartMotor servos. Note that Class 6 motors require these firmware versions: for Class 6 M-style, 6.0.2.54 or later; for Class 6 D-style, 6.4.2.54 or later.

Combitronic Technology

The most unique feature of the SmartMotor is its ability to communicate with other SmartMotors and share resources using Moog Animatics' Combitronic™ technology. Combitronic is a protocol that operates over a standard CAN interface. It may coexist with CANopen and other protocols. It requires no single dedicated controller¹ to operate. Each SmartMotor connected to the same network communicates on an equal footing, sharing all information, and therefore, sharing all processing resources.

For additional details, see the [SmartMotor™ Developer's Guide](#).

¹Moog Animatics has replaced the terms "master" and "slave" with "controller" and "follower", respectively.

Safety Information

This section describes the safety symbols and other safety information.

Safety Symbols

The manual may use one or more of these safety symbols:



WARNING: This symbol indicates a potentially nonlethal mechanical hazard, where failure to comply with the instructions could result in serious injury to the operator or major damage to the equipment.



CAUTION: This symbol indicates a potentially minor hazard, where failure to comply with the instructions could result in slight injury to the operator or minor damage to the equipment.

NOTE: Notes are used to emphasize non-safety concepts or related information.

Other Safety Considerations

The Moog Animatics SmartMotors are supplied as components that are intended for use in an automated machine or system. As such, it is beyond the scope of this manual to attempt to cover all the safety standards and considerations that are part of the overall machine/system design and manufacturing safety. Therefore, this information is intended to be used only as a general guideline for the machine/system designer.

It is the responsibility of the machine/system designer to perform a thorough "Risk Assessment" and to ensure that the machine/system and its safeguards comply with the safety standards specified by the governing authority (for example, ISO, OSHA, UL, etc.) for the site where the machine is being installed and operated. For more details, see Machine Safety on page 9.

Motor Sizing

It is the responsibility of the machine/system designer to select SmartMotors that are properly sized for the specific application. Undersized motors may: perform poorly, cause excessive downtime or cause unsafe operating conditions by not being able to handle the loads placed on them. The *System Best Practices* document, which is available on the Moog Animatics website, contains information and equations that can be used for selecting the appropriate motor for the application.

Replacement motors must have the same specifications and firmware version used in the approved and validated system. Specification changes or firmware upgrades require the approval of the system designer and may require another Risk Assessment.

Environmental Considerations

It is the responsibility of the machine/system designer to evaluate the intended operating environment for dust, high-humidity or presence of water (for example, a food-processing environment that requires water or steam wash down of equipment), corrosives or chemicals that may come in contact with the machine, etc. Moog Animatics manufactures specialized IP-rated motors for operating in extreme conditions. For details, see the *Moog Animatics Product Catalog*.

Machine Safety

In order to protect personnel from any safety hazards in the machine or system, the machine/system builder must perform a "Risk Assessment", which is often based on the ISO 13849 standard. The design/implementation of barriers, emergency stop (E-stop) mechanisms and other safeguards will be driven by the Risk Assessment and the safety standards specified by the governing authority (for example, ISO, OSHA, UL, etc.) for the site where the machine is being installed and operated. The methodology and details of such an assessment are beyond the scope of this manual. However, there are various sources of Risk Assessment information available in print and on the internet.

NOTE: The next list is an example of items that would be evaluated when performing the Risk Assessment. Additional items may be required. The safeguards must ensure the safety of all personnel who may come in contact with or be in the vicinity of the machine.

In general, the machine/system safeguards must:

- Provide a barrier to prevent unauthorized entry or access to the machine or system. The barrier must be designed so that personnel cannot reach into any identified danger zones.
- Position the control panel so that it is outside the barrier area but located for an unrestricted view of the moving mechanism. The control panel must include an E-stop mechanism. Buttons that start the machine must be protected from accidental activation.
- Provide E-stop mechanisms located at the control panel and at other points around the perimeter of the barrier that will stop all machine movement when tripped.
- Provide appropriate sensors and interlocks on gates or other points of entry into the protected zone that will stop all machine movement when tripped.
- Ensure that if a portable control/programming device is supplied (for example, a hand-held operator/programmer pendant), the device is equipped with an E-stop mechanism.

NOTE: A portable operation/programming device requires *many* additional system design considerations and safeguards beyond those listed in this section. For details, see the safety standards specified by the governing authority (for example, ISO, OSHA, UL, etc.) for the site where the machine is being installed and operated.

- Prevent contact with moving mechanisms (for example, arms, gears, belts, pulleys, tooling, etc.).
- Prevent contact with a part that is thrown from the machine tooling or other part-handling equipment.
- Prevent contact with any electrical, hydraulic, pneumatic, thermal, chemical or other hazards that may be present at the machine.
- Prevent unauthorized access to wiring and power-supply cabinets, electrical boxes, etc.
- Provide a proper control system, program logic and error checking to ensure the safety of all personnel and equipment (for example, to prevent a run-away condition). The control system must be designed so that it does not automatically restart the machine/system after a power failure.
- Prevent unauthorized access or changes to the control system or software.

Documentation and Training

It is the responsibility of the machine/system designer to provide documentation on safety, operation, maintenance and programming, along with training for all machine operators, maintenance technicians, programmers, and other personnel who may have access to the machine. This documentation must include proper lockout/tagout procedures for maintenance and programming operations.

It is the responsibility of the operating company to ensure that:

- All operators, maintenance technicians, programmers and other personnel are tested and qualified before acquiring access to the machine or system.
- The above personnel perform their assigned functions in a responsible and safe manner to comply with the procedures in the supplied documentation and the company safety practices.
- The equipment is maintained as described in the documentation and training supplied by the machine/system designer.

Additional Equipment and Considerations

The Risk Assessment and the operating company's standard safety policies will dictate the need for additional equipment. In general, it is the responsibility of the operating company to ensure that:

- Unauthorized access to the machine is prevented at all times.
- The personnel are supplied with the proper equipment for the environment and their job functions, which may include: safety glasses, hearing protection, safety footwear, smocks or aprons, gloves, hard hats and other protective gear.
- The work area is equipped with proper safety equipment such as first aid equipment, fire suppression equipment, emergency eye wash and full-body wash stations, etc.
- There are no modifications made to the machine or system without proper engineering evaluation for design, safety, reliability, etc., and a Risk Assessment.

Safety Information Resources

Additional SmartMotor safety information can be found on the Moog Animatics website; open the topic "Controls - Notes and Cautions" located at:

<https://www.animatics.com/support/downloads/knowledgebase/controls---notes-and-cautions.html>

OSHA standards information can be found at:

<https://www.osha.gov/law-regs.html>

ANSI-RIA robotic safety information can be found at:

<http://www.robotics.org/robotic-content.cfm/Robotics/Safety-Compliance/id/23>

UL standards information can be found at:

<http://ulstandards.ul.com/standards-catalog/>

ISO standards information can be found at:

<http://www.iso.org/iso/home/standards.htm>

EU standards information can be found at:

<http://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/index.en.htm>

Additional Documents

The Moog Animatics website contains additional documents that are related to the information in this manual. Please refer to these lists.

Related Guides

- Moog Animatics SmartMotor™ Installation & Startup Guides
<http://www.animatics.com/install-guides>
- *SmartMotor™ Developer's Guide*
<http://www.animatics.com/smartmotor-developers-guide>
- *SmartMotor™ System Best Practices Application Note*
<http://www.animatics.com/system-best-practices-application-note>

In addition to the documents listed above, guides for fieldbus protocols and more can be found on the website: <https://www.animatics.com/support/downloads/manuals.html>

Other Documents

- SmartMotor™ Certifications
<https://www.animatics.com/certifications.html>
- *SmartMotor Developer's Worksheet*
(interactive tools to assist developer: Scale Factor Calculator, Status Words, CAN Port Status, Serial Port Status, RMODE Decoder and Syntax Error Codes)
<https://www.animatics.com/support/downloads/knowledgebase.html>
- *Moog Animatics Product Catalog*
<http://www.animatics.com/support/moog-animatics-catalog.html>

Additional Resources

The Moog Animatics website contains useful resources such as product information, documentation, product support and more. Please refer to these addresses:

- General company information:
<http://www.animatics.com>
- Product information:
<http://www.animatics.com/products.html>
- Product support (Downloads, How-to Videos, Forums and more):
<http://www.animatics.com/support.html>
- Contact information, distributor locator tool, inquiries:
<https://www.animatics.com/contact-us.html>
- Applications (Application Notes and Case Studies):
<http://www.animatics.com/applications.html>

Homing Overview

The Moog Animatics SmartMotor has an integrated Homing feature based on the CiA 402 CANopen specification. Homing is the process of finding the zero position of an application relative to a home switch on an axis. The home switch can be one of the limit switches or another switch placed within the range of travel.

Homing Control Variables

The homing operation is controlled by the following variables:

Homing Method - the homing method determines the following behavior:

- The type of homing signal (positive limit switch, negative limit switch, home switch)
NOTE: The electrical polarity of the limit switches is not configurable (refer to the relevant SmartMotor Installation and Startup Guide for more details)
- The initial direction of motion
- If the home position is relative to an encoder index mark or the edge of the home switch
- The style of home switch to use

Homing Speeds - there are two homing speeds (values are given in motor counts):

- The speed used to find the home switch, usually the faster of the two.
- The speed used to find the home position, either an index pulse or edge of the home switch. It is usually the slower of the two speeds and provides the most accuracy and repeatability.

Homing Acceleration - indicates the acceleration and deceleration values to be used during the homing operation. The values are given in motor counts.

Home Offset - the difference between the home position found during the homing operation and the zero position for the application.

Halt Option* - determines the action of the motor when the CAN control word Halt bit is set.

- 1 - Decelerate on the profile deceleration
- 2 - Slow down on Quick Stop Deceleration

*Used with the [CAN Interruptible Homing](#) style

Quick Stop Deceleration*- the deceleration value used to stop the motor if the Halt Option is set to 2 and the CAN control word Halt bit is set to 1.

*Used with the [CAN Interruptible Homing](#) style

Once these values have been set, the homing operation is controlled and monitored using bits in the CAN control word and status word.

The following two examples illustrate possible homing scenarios.

Example: Homing Method 1

The following figure illustrates Homing Method 1, homing on the first index mark to the right of the negative limit switch. A positive Home Offset value sets the application zero position to the right of the home position; a negative Home Offset value sets it to the left.

Homing Method 1: Home on the Negative Limit switch, End on an Encoder Index pulse

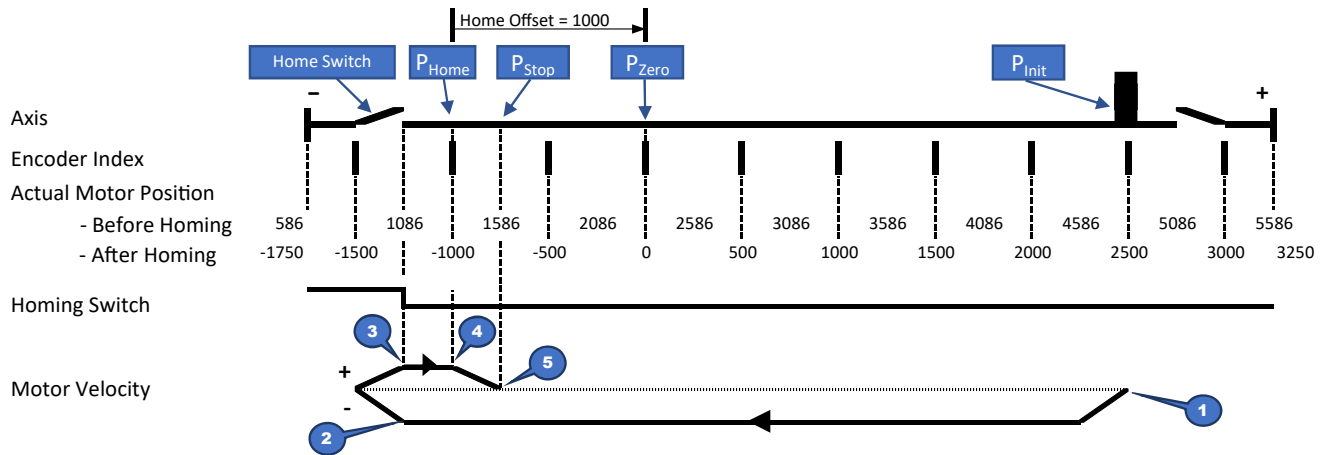
P_{Init} = The position of the actuator before the homing operation starts

P_{Home} = The machine home position found during the homing operation

P_{Stop} = The position of the actuator after the homing operation completes.

P_{Zero} = The zero position for the application, $P_{Zero} = P_{Home} + HomeOffset$

Home Offset = The difference between the machine home position, found during homing, and the zero position for the application



Homing Example - Homing Method 1

Homing Steps:

1. The homing operation starts, and the motor moves towards the negative limit switch.
2. The negative limit switch is detected, stopping the motor.
3. The motor moves in the positive direction until the limit switch releases and then starts looking for the next encoder index mark.
4. The position of the index mark is captured, the motor ramps to a stop and the application zero position is calculated. The actual and calculated motor positions are updated so that P_{Zero} location reports a value of zero (0).
5. The motor comes to rest, which completes the homing operation.

Example: Homing Method 3

The following figure illustrates Homing Method 3, homing on the first index mark to the left of the positive home switch. The Home Offset value is negative, moving the application zero position to the left of the home position.

Homing Method 3: Homing On Low Side of a Positive Home Switch and Index Pulse

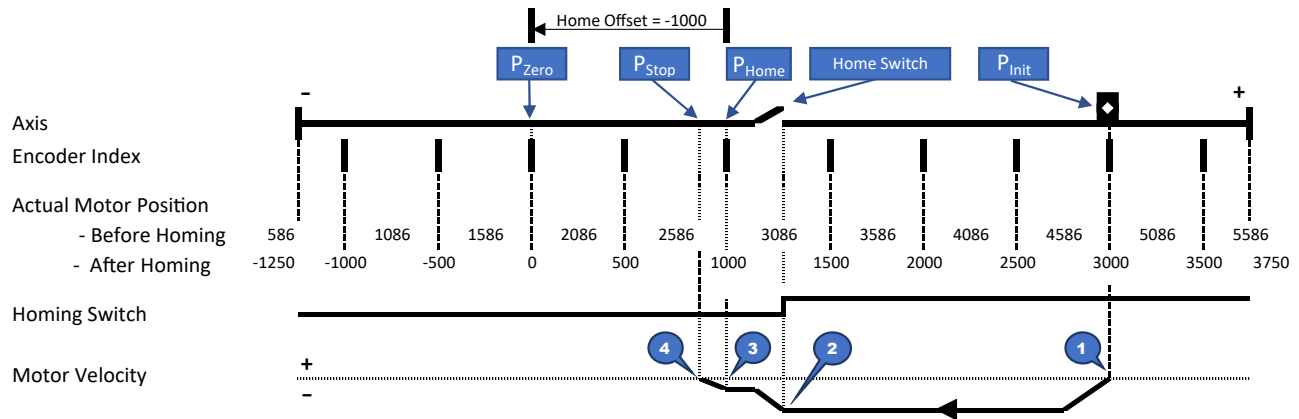
P_{Init} = The position of the actuator before the homing operation starts

P_{Home} = The machine home position found during the homing operation

P_{Stop} = The position of the actuator after the homing operation completes.

P_{Zero} = The zero position for the application, $P_{Zero} = P_{Home} + HomeOffset$

HomeOffset = The difference between the machine home position, found during homing, and the zero position for the application



Homing Example - Homing Method 3

Homing Steps:

1. The homing operation starts, and the motor moves towards the negative limit switch.
2. The home switch goes low, the motor slows and starts looking for the next encoder index mark.
3. The position of the index mark is captured, the motor ramps to a stop and the application zero position is calculated.
4. The motor comes to rest, which completes the homing operation.

Animatics Style vs. CAN Interruptible Homing

The **Class 6** SmartMotor supports two styles of homing:

- Moog Animatics ("Animatics Style") Homing - controls the motor in a manner similar to the Moog Animatics command interface but uses the CAN control word homing bits in a non-standard manner. This homing style does not allow for interrupting or resuming a homing operation.
- CAN Interruptible Homing - controls the motor using the homing bits of the CAN control word according to the CANopen specification. This homing style allows the homing operation to be interrupted and resumed.

The difference between the two styles is in how the operation is interrupted or stopped.

The **Class 5** SmartMotor supports the Animatics Style Homing logic and a limited number of homing methods. For more details, see Homing Methods on page 17.

When the motor is configured for Animatics Style Homing:

- The homing operation can be halted using the default motor ramp, thus aborting the homing operation, similar to issuing an X-Stop command from the Terminal View in the SMI software.
- The homing operation can be halted using the Quick Stop deceleration, thus aborting the homing operation, similar to issuing an S-stop command from the Terminal View in the SMI software.
- The homing operation cannot be interrupted and then resumed. If it is interrupted, that homing operation is aborted and a new one must be started.

When the motor is configured for CAN Interruptible Homing, the homing operation can be:

- Halted using the motor ramp selected by the Halt option. The homing operation can be resumed or aborted depending on the Homing control word bit settings.
- Interrupted and resumed. When the homing operation is interrupted, the motor will continue moving until it halts at the end of the current segment. When resumed, if the homing operation was not completed in that segment, the motor will continue from that point.

For more details, see CAN Control Word Homing Bits on page 22.

The motor defaults to Animatics Style Homing on power up. CAN Interruptible Homing can be selected issuing one of the following commands: (the commands can be placed at the beginning of a user program or entered from the SMI software Terminal View)

- CANCTL(61,0), enables Animatics Style Homing
- CANCTL(61,1), enables CAN Interruptible Homing

Homing Methods

This section describes the available homing methods for the Class 5 and Class 6 SmartMotor servos.

Methods by Motor Class

Class 5 SmartMotors support Homing Methods:

- 1 - 2: Home on a limit switch, the home position is relative to an index pulse
- 17 - 18: Home on a limit switch, the home position is relative to the edge of the home switch
- 33 - 34: Home on the nearest index pulse
- 35: Home on the current position

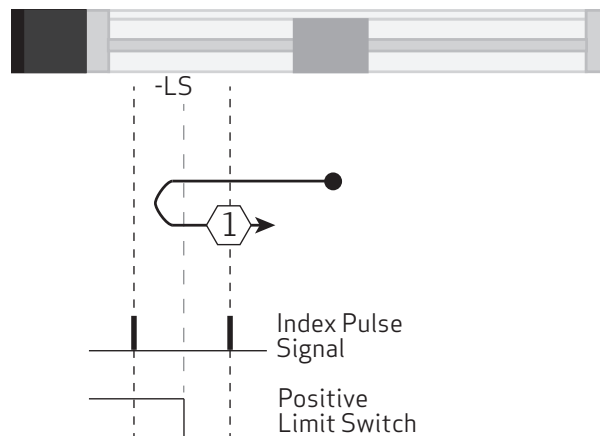
Class 6 SmartMotors support Homing Methods:

- 1 - 14: The home position is relative to an index pulse
- 17 - 30: The home position is relative to the edge of the home switch
- 33 - 34: Home on the nearest index pulse
- 35: Home on the current position

Method Descriptions

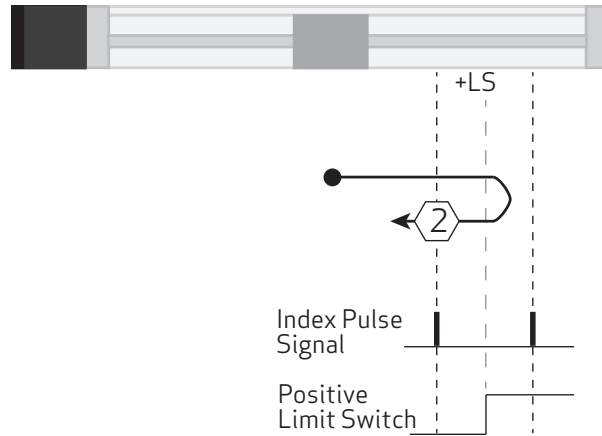
Method 1: Homing on negative limit switch and index pulse

The initial direction of movement shall be to the left if the negative limit switch is inactive. The home position shall be at the first index pulse to the right of the position where the negative limit switch becomes inactive.



Method 2: Homing on positive limit switch and index pulse

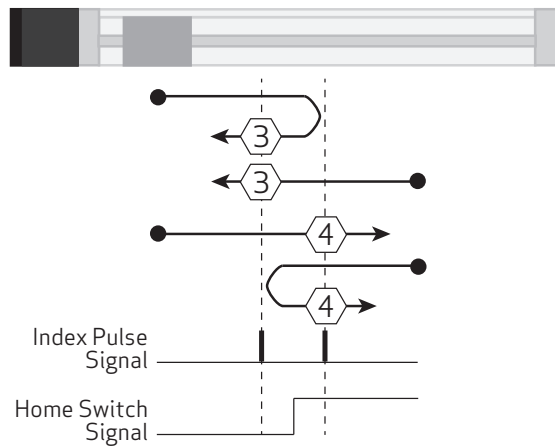
The initial direction of movement shall be rightward if the positive limit switch is inactive. The position of home shall be at the first index pulse to the left of the position where the positive limit switch becomes inactive.



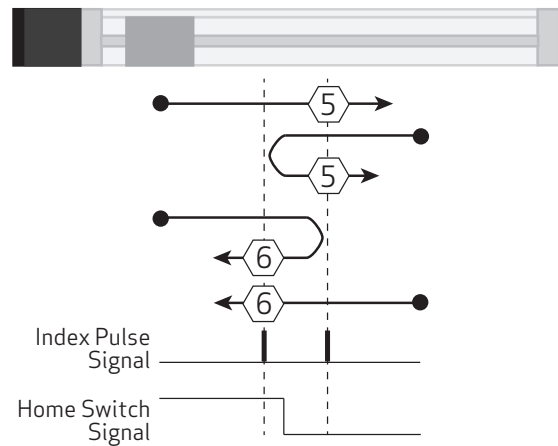
Method 3 and 4: Homing on positive home switch and index pulse Method 5 and 6: Homing on negative home switch and index pulse

The initial direction of movement depends on the state of the home switch. The home position will be at the index pulse to the left or right of the point where the home switch changes state. If the initial position is situated so that the direction of movement reverses during homing, the reversal may take place anywhere after the home switch changes state.

Methods 3 & 4



Methods 5 & 6



Method 7 to 14: Homing on home switch and index pulse

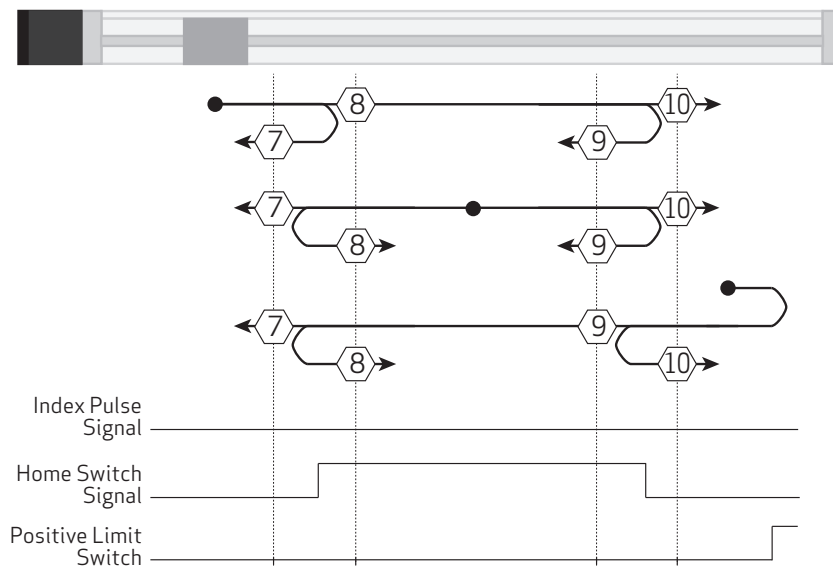
These methods use a home switch in mid-travel. The switch has a "momentary" action as the axis's position sweeps past the switch. The initial direction of movement depends on the state of the home switch.

If the home switch is not active at the start of homing:

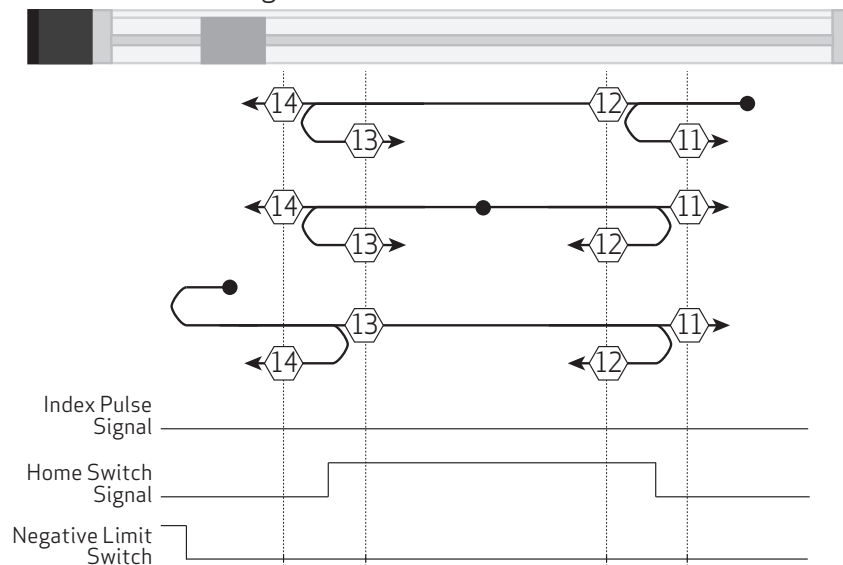
- Methods 7 to 10, the initial direction of movement shall be to the right
- Methods 11 to 14, the initial direction of movement shall be to the left

If the home switch is active at the start of the motion, the initial direction of motion shall be dependent on the edge being sought. The home position shall be at the index pulse on either side of the rising or falling edges of the home switch as shown in the following figures. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

Methods 7-10: Positive Initial Motion



Methods 11-14: Negative Initial Motion

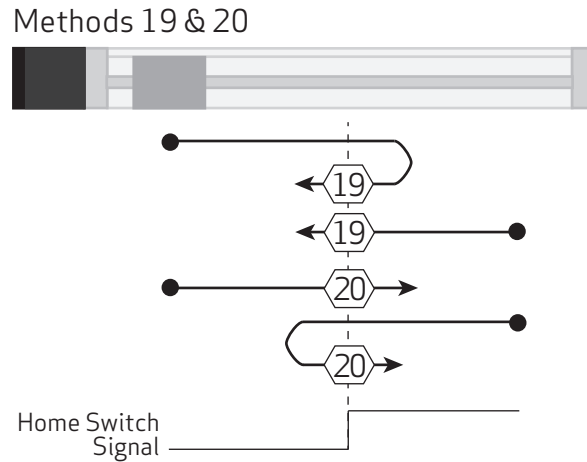


Method 15 and 16: Reserved

These methods are reserved.

Method 17 to 30: Homing without index pulse

These methods are the same as methods 1 to 14 except that the home position is relative to the edge of the home switch instead of an encoder index mark. For example, methods 19 and 20 are similar to methods 3 and 4 as shown.

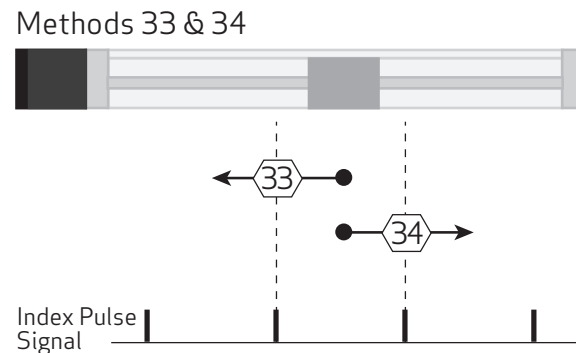


Method 31 and 32: Reserved

These methods are reserved.

Method 33 and 34: Homing on index pulse

The initial direction of homing is left or right, respectively. The home position shall be at the index pulse found in the selected direction as shown.



Method 35: Homing on index pulse

In this method, the current position shall be taken to be the home position. This method does not require the drive device to be in enabled operational state.

In this method, the current position shall be taken to be the home position. This method does not require the drive device to be in enabled operational state.

Communicating with the SmartMotor

CANopen communicates using a set of well-defined objects. Each homing parameter has an assigned Object Number, Object Index and Data Type.

EtherNet/IP communicates using a Device Profile Object and Device Attributes. The Class 6 SmartMotor has defined vendor specific attributes for the Position Control Supervisor object to communicate with the SmartMotor homing logic.

Homing Objects

Description	CANopen					EtherNet/IP Position Control Supervisor	Serial Command (Class 6 Only)
	Object Index / Sub- Index	Data Type	Access	Required	Default	Attribute (Class 6 Only)	
Control word	6040h 0	Unsigned 16-bit	rw	Yes		120	G,X,S CANCTL (68,x) CANCTL (69,x)
Status word	6041h 0	Unsigned 16-bit	ro	Yes		121	RCAN(3)
Homing method	6098h 0	Signed 8-bit	rw	Yes	0	122	HM_MTHD
Homing accel/decel	609Ah 0	Unsigned 32-bit	rw	No	4	123	HM_ADT
Homing speeds - during search for switch	6099h 1	Unsigned 32-bit	rw	Yes	0	124	HM_VTS
Homing speeds - during search for zero	6099h 2	Unsigned 32-bit	rw	Yes	0	125	HM_VTZ
Home offset	607Ch 0	Signed 32-bit	rw	No	0	126	HM_OSET
Halt option	605Dh, 0	Signed 16-bit	rw	No	1	127	RCAN(62) CANCTL (62,x)
Quick stop deceleration	6085h 0	Unsigned 32-bit	rw	No	0x7FFFFFFF	128	RCAN(63) CANCTL (63,x)

rw – read/write access, ro – read only access

CAN Control Word Homing Bits

Two bits of the CAN control word are used to control the homing operation.

15						9	8	7	6	5	4	3	2	1	0	
							Halt					Homing Start				

Homing Control Word Bits

NOTE: Changing the motor from Homing mode to Position, Velocity or Torque mode will abort an in-progress homing operation.

Animatics Homing Control Word Usage

Bit 4	Bit 8	Action
0	0	Homing is not active
0->1	0	Start homing operation
1->0	0	Halt homing operation using default ramp (X Stop), abort homing operation
1	0->1	Halt homing operation using a hard stop (S Stop), abort homing operation
1	1->0	No operation, Bit 4 must be cycled (1->0->1) to start a new homing operation

Description:

- Setting bit 4 will start a homing operation, the value must transition from a 0 to a 1. Homing operations cannot be interrupted and resumed. A Homing operation will always start in the initial direction dictated by the homing Method.
- Clearing bit 4 will stop the homing operation, halting the motor near the current location, equivalent to an X Stop command
- Setting bit 8 will stop the homing operation, halting the motor near the current position, equivalent to an S Stop command
- Clearing bit 8 will allow a homing operation to be started. In order to start the homing operation bit 4 must transition from a 0 to a 1.

CANopen Interruptible Homing Control Word Usage

Bit 4	Bit 8	Action
0	0	Homing is not active
0->1	0	Start a new homing operation or resume an in-progress homing operation
1->0	0	Interrupt the homing operation at the end of the current segment.
1	0->1	Halt the motor according to the halt option code. (See CAN Object 605Dh)
1	1->0	Resume the in-progress homing operation
0	1->0	Abort any in-progress homing operation

Description:

- Setting bit 4 will start a homing operation if one is not in-progress or will continue an in-progress homing operation from the current position.
- Clearing bit 4 will interrupt the active homing operation. The motor will continue to move until the end of the current Homing Method segment. If the current segment is the last segment, then the homing operation is complete and will no longer be in-progress.
- Setting bit 8 will immediately halt the motor near the current position. Any changes of Bit 4 will be ignored while Bit 8 is set.
- Clearing bit 8 will:
 - Continue an in-progress homing operation from the current position if bit 4 is set
 - Abort an in-progress homing operation if bit 4 is clear.

CAN Status Word Homing Bits

Three bits of the CAN status word are used to monitor the state homing operation.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
		Homing Error	Homing Attained		Target Reached										

Homing Status Word Bits

The following table shows the definition of status word bits 10, 12 and 13.

Bit 13	Bit 12	Bit 10	Definition
0	0	0	Homing operation is in progress
0	0	1	Homing operation is interrupted or not started
0	1	0	Homing is attained, but target is not reached
0	1	1	Homing operation is completed successfully
1	0	0	Homing error occurred; velocity is not 0
1	0	1	Homing error occurred; velocity is 0
1	1	X	Reserved

Examples

These examples demonstrate how to configure and control the homing operation using the CANopen 402 motion profile control word and status word. See the EtherNet/IP and Serial command sections for details on using these alternate interfaces.

NOTE:

- The user must configure the parameters listed in the Homing Parameters table before starting the homing operation.
- The examples assume the motor is configured for Homing Method 1.
- Limit switches must be physically connected in this example. The negative limit switch will be used as the home reference.

Configure the Homing Operation, Homing Method 1

The following table provides a summary of CAN objects to configure before the homing operation is started.

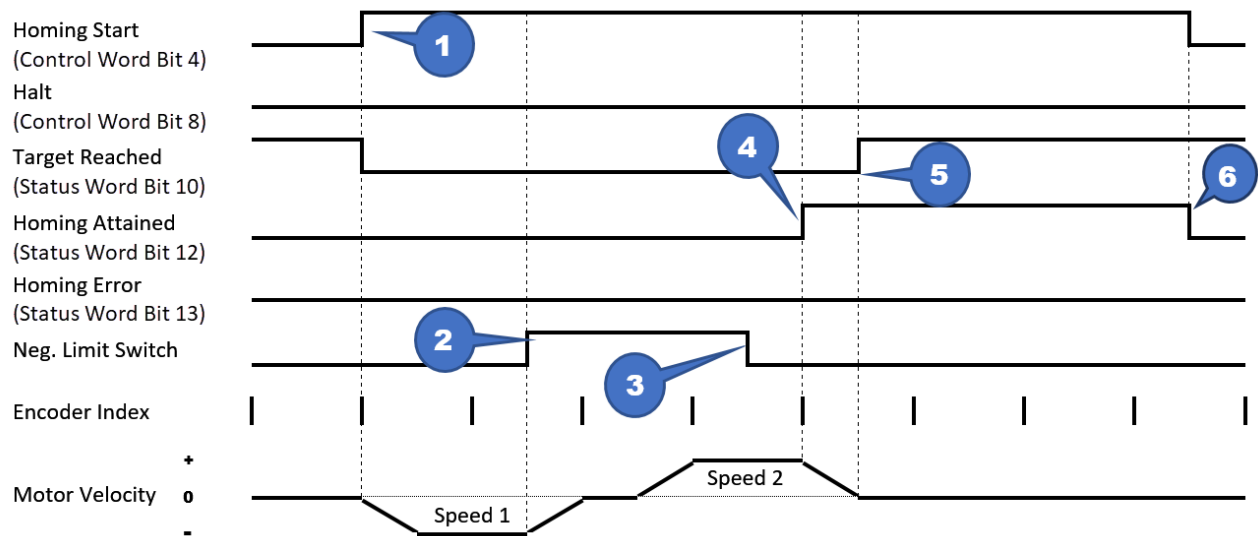
Description	Read / Write	Index Object Code	Sub Index	Data	
				Length	Dec / Hex / Binary
Reset status word	W	6040h	00	02	128 0080h 0000 0000 1000 0000b
Set homing method	W	6098h	00	01	1 01h
Set homing speed 1	W	6099h	01	04	100000 000186A0h
Set homing speed 2	W	6099h	02	04	10000 00002710h
Set homing acceleration	W	609Ah	00	04	100 00000064h
Set homing offset	W	607Ch	00	04	1000 000003E8h

Description	Read / Write	Index Object Code	Sub Index	Data	
				Length	Dec / Hex / Binary
*Set Motor Mode to Homing (HM)	W	6060h	00	01	6 06h
*Change state: Ready to switch on	W	6040h	00	02	6 0006h 0000 0000 0000 0110b
*Change state: Switched on	W	6040h	00	02	7 0007h 0000 0000 0000 0111b
*Enable operation	W	6040h	00	02	15 000Fh 0000 0000 0000 1111b
*These objects are required for the CANopen operation and not used in the EtherNet/IP implementation (refer to the CiA 402 Drive State machine (PDSFSA) for more details).					

Start a New Homing Operation

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
0	0	0	0	1	Before the homing operation starts:
1	0	0	0	0	<ol style="list-style-type: none"> 1. Set the Homing Start bit. 2. The motor moves in the negative direction, at Homing Speed 1, until the negative limit switch is detected and then ramps to a stop. 3. The motor then moves in a positive direction, at Homing Speed 2, while looking for the negative limit switch to release and then for the next encoder index mark.
1	0	0	1	0	<ol style="list-style-type: none"> 4. The index mark is detected. <ul style="list-style-type: none"> • The home position is set to the encoder index position. • The zero position is calculated using the home position and home offset. • The motor begins ramping to a stop.
1	0	0	1	1	5. The motor comes to a halt; the homing operation is complete.
0	0	0	0	1	6. The Homing Attained status bit resets when the Homing Start control word bit is reset.

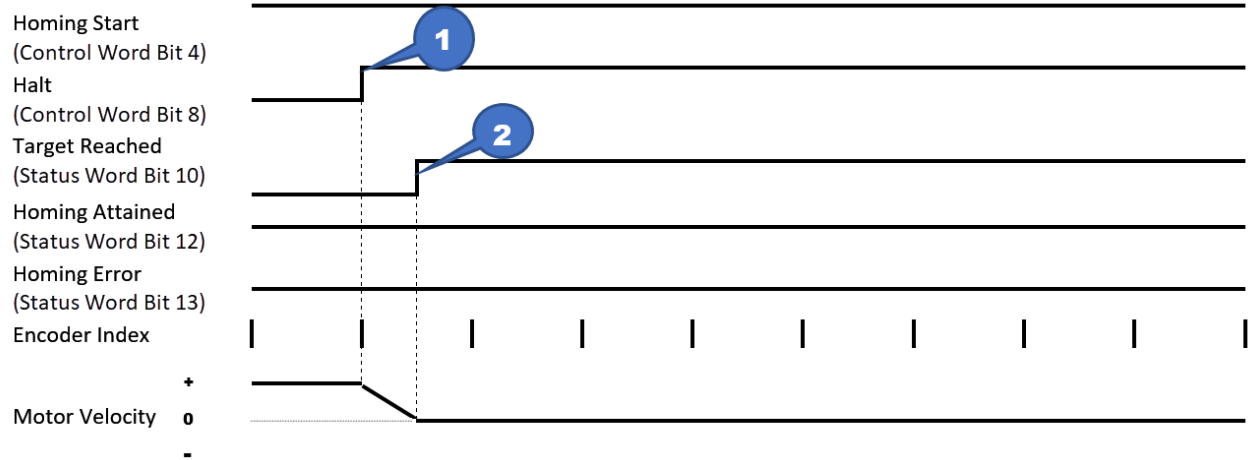
The event timing is as follows:



Halt the Motor During a Homing Operation

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	0	0	0	0	A homing operation is in progress.
1	1	0	0	0	1. Set the Halt bit to stop the motor.
1	1	0	0	1	2. The motor comes to a halt; the motor velocity is zero.

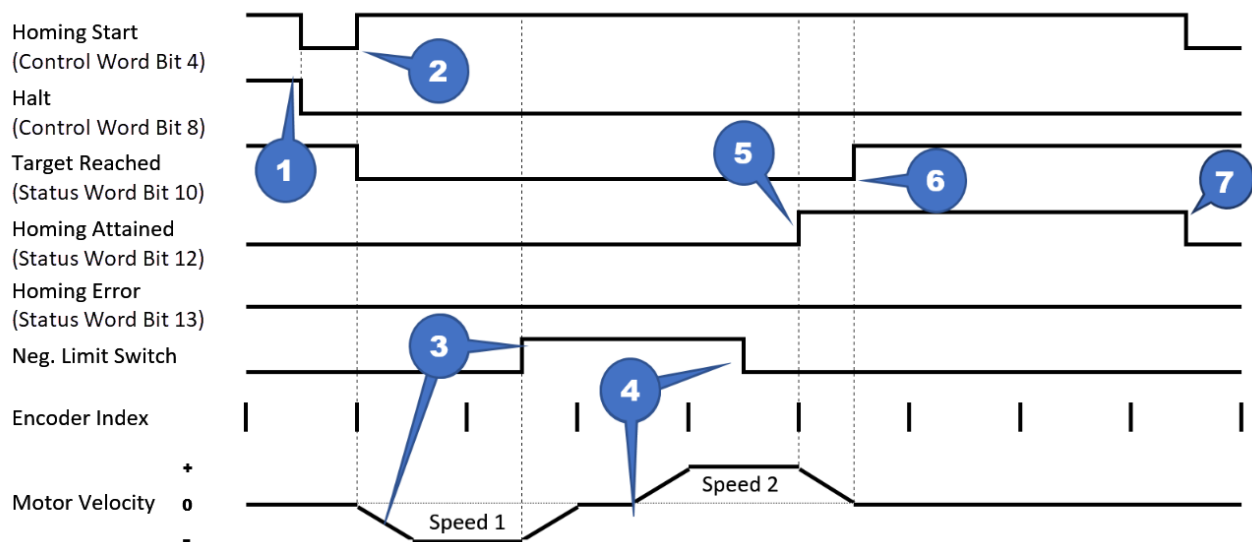
The event timing is as follows:



Resume the Halted Homing Operation - Animatics Homing

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	1	0	0	1	The motor is halted; the homing operation is aborted.
0	0	0	0	1	1. Reset homing control word Homing Start and Halt bits. No action - the previous homing operation is aborted.
1	0	0	0	0	2. Set the Homing Start bit. 3. The motor moves in the negative direction, at Homing Speed 1, until the negative limit switch is detected and then ramps to a stop. 4. The motor then moves in a positive direction, at Homing Speed 2, while looking for the negative limit switch to release and then for the next encoder index mark.
1	0	0	1	0	5. The index mark is detected. <ul style="list-style-type: none"> The home position is set to the encoder index position. The zero position is calculated using the home position and home offset. The motor begins ramping to a stop.
1	0	0	1	1	6. The motor comes to a halt; the homing operation is complete.
0	0	0	0	1	7. The Homing Attained status bit resets when the Homing Start control word bit is reset.

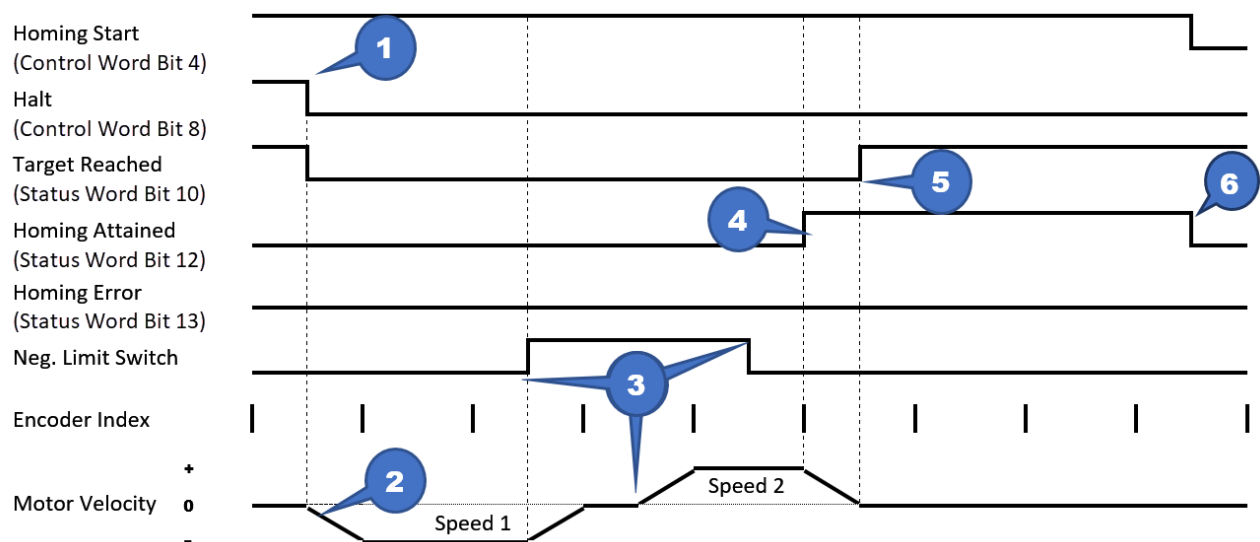
The event timing is as follows:



Resume the Halted Homing Operation - CAN Interruptible Homing

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	1	0	0	1	The motor is halted; the homing operation is suspended.
1	0	0	0	0	<ol style="list-style-type: none"> 1. Reset the CAN control word Halt bit. 2. The homing operation immediately continues moving in the direction/speed it was traveling when stopped, in this case toward the negative limit switch at Homing Speed 1. 3. The negative limit switch is detected. The motor then moves in a positive direction at Homing Speed 2, while looking for the negative limit switch to release and then for the next encoder index mark.
1	0	0	1	0	<ol style="list-style-type: none"> 4. The index mark is detected. <ul style="list-style-type: none"> • The home position is set to the encoder index position. • The zero position is calculated using the home position and home offset. • The motor begins ramping to a stop.
1	0	0	1	1	5. The motor comes to a halt; the homing operation is complete.
0	0	0	0	1	6. The Homing Attained status bit resets when the Homing Start control word bit is reset.

The event timing is as follows:



Homing-Specific CANopen Objects

Refer to the following table for a list and description of the homing-specific CANopen objects. For complete details on these objects, see the [SmartMotor CANopen Guide](#).

CANopen Object	Description
Object 6040h: Control Word	This object, the control word, is the primary method of commanding motion in the SmartMotor.
Object 6041h: Status Word	This object, the status word, indicates the current state of the drive
Object 605Dh: Halt Option Code	This object determines what action should be taken if the halt bit (bit 8) is set in Control Word object (6040h).
Object 607Ch: Home Offset	This object shifts the origin of the actual position when the Homing (HM) mode is executed.
Object 6085h: Quick Stop Deceleration	This object is used to stop the drive with the Quick Stop function, which is commanded from bit 2 of the Control Word object (6040h).
Object 6098h: Homing Method	This object selects the method used in Homing (HM) mode. This must be set before starting a homing process, and it should not be changed while HM mode is actively seeking home.
Object 6099h: Homing Speeds	This object only applies to Homing (HM) mode. The homing profile will accelerate to these speeds depending on the segment of the homing routine that is in use.
Object 609Ah: Homing Acceleration	This object is the acceleration and deceleration in Homing (HM) mode.

EtherNet/IP Homing (Class 6 Only)

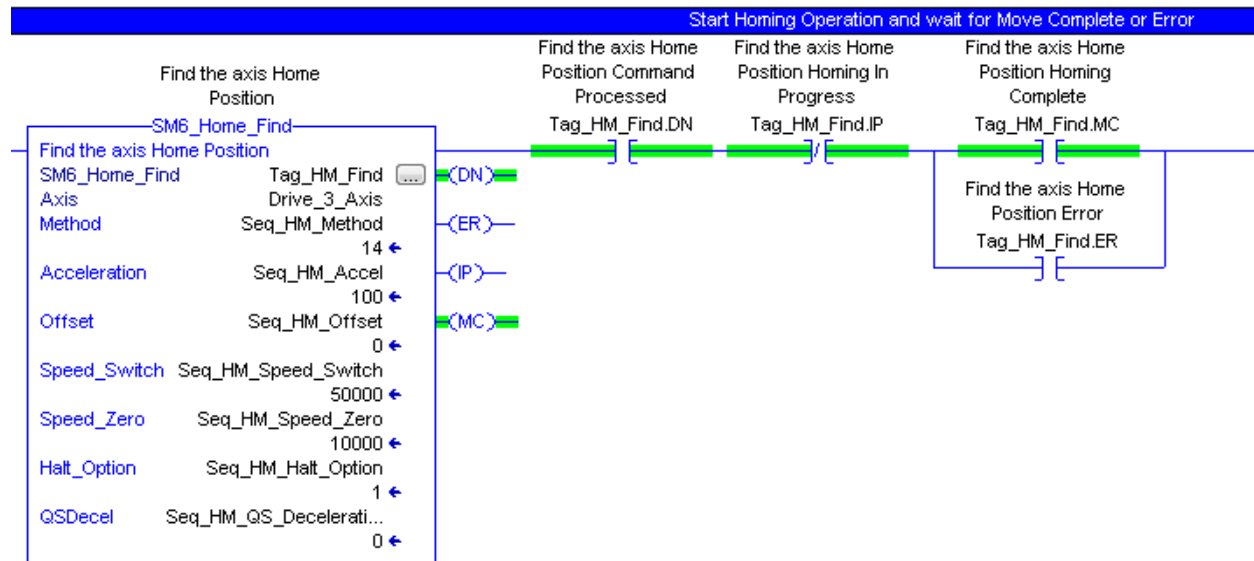
The Moog Animatics Class 6 SmartMotor communicates on EtherNet/IP networks using the Position Controller Device profile consisting of the Position Controller Supervisor Object and the Position Controller Object. Vendor Specific Attributes 120 - 129 have been added to the Position Controller Supervisor Object to communicate with the built-in CiA 402 CANopen homing logic.

Moog Animatics provides example Add On Instructions (AOIs) for the Rockwell Studio 5000 Logix Designer PLC programming environment to communicate with Rockwell PLCs. Two AOIs have been added to demonstrate the homing functionality: SM6_Home_Find to setup and initiate a homing operation, and SM6_Set_Attribute2 to manipulate the CAN control word and monitor the CAN status word.

The following examples provide ladder logic diagram snippets that demonstrate their use.

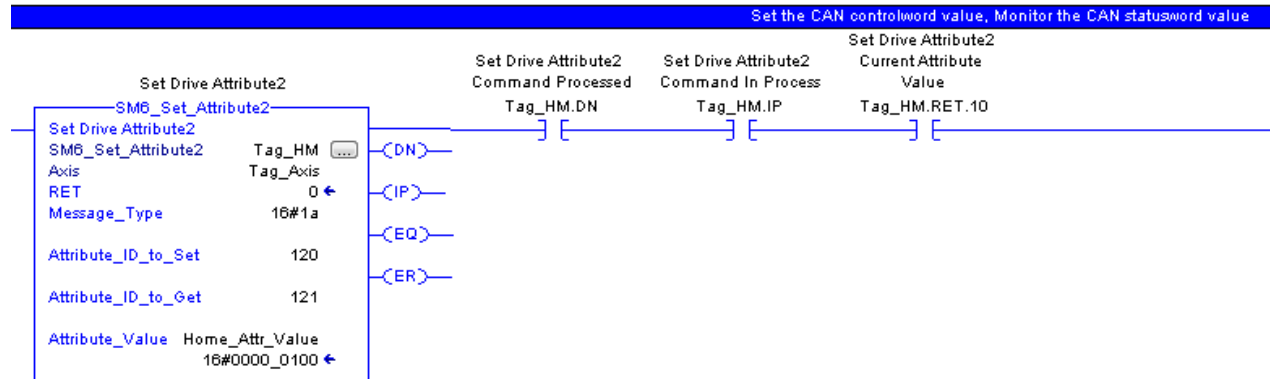
Example 1: Configure and Start a Homing Operation

This example configures and starts a homing operation and then waits for the operation to be complete.



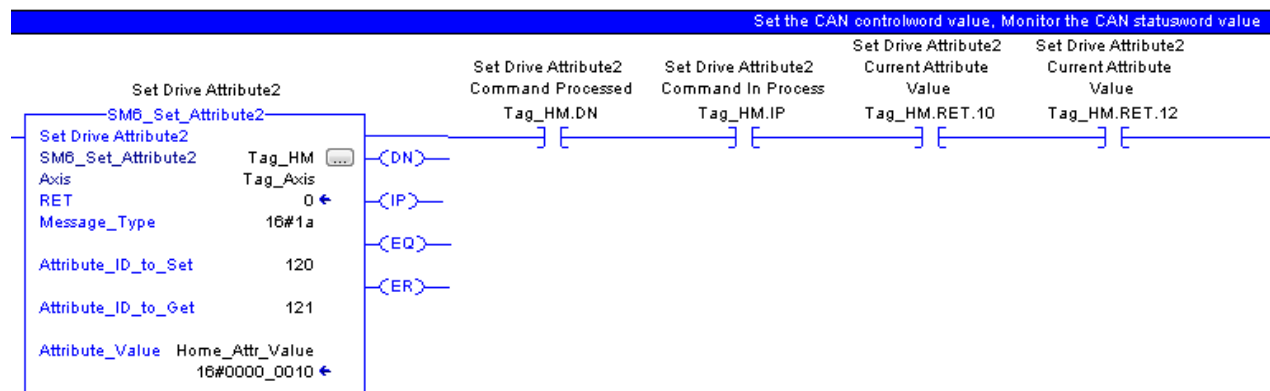
Example 2: Halt Motor During a Homing Operation

This example halts (stops) the motor during a homing operation and then waits for the motor to be halted.



Example 3: Resume the Halted Homing Operation

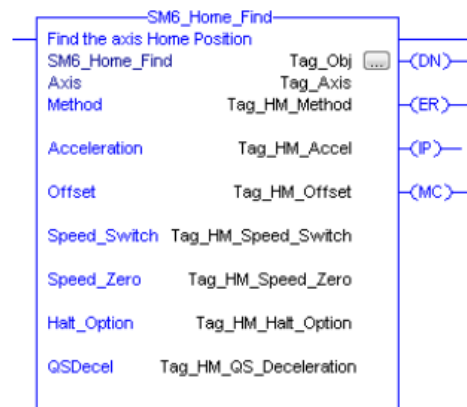
This example resumes the halted homing operation and then waits for it to be completed



NOTE: When using the Animatics Homing style, the Attribute value must cycle the Home Start bit from a 0 to 1 to restart the homing operation.

Example 4: SM6_Home_Find - Find the Axis Home Position

This example finds the home position of the axis.



Description

The Find Home feature of the Animatics motor uses the built-in CiA 402 homing logic in the motor.

Operands

Operand	Data Type	Operand Type	Description
SM6_Home_Find	SM6_Home_Find	Tag	Control tag for this AOI
Axis	SM6_Axis	Tag	The targeted drive
Method	DINT	Immediate Value	Homing method
Acceleration	DINT	Immediate Value	Homing acceleration
Offset	DINT	Immediate Value	Homing offset
Speed_Switch	DINT	Immediate Value	Speed to homing switch
Speed_Zero	DINT	Immediate Value	Speed to zero position
Halt_Option	SINT	Immediate Value	Halt option code: 1 - Slow ramp 2 - Quick stop ramp
QSDecel	DINT	Immediate Value	Quick stop deceleration

Structure

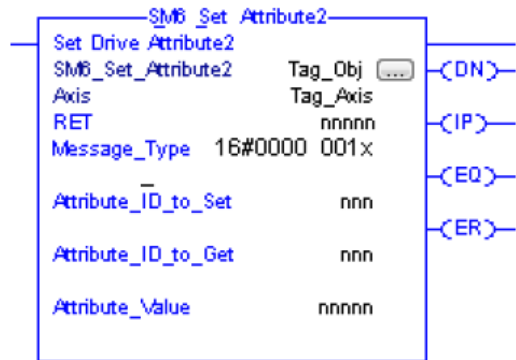
Field	Type	Description
.DN	BOOL	Set when all of the commands to setup and execute the find Home operation are sent Cleared when a Find Home operation is started/restarted
.ER	BOOL	Set when an error response is received from the motor Cleared when a Find Home operation is started/restarted
.IP	BOOL	Set while sending commands to the motor Cleared when the motor comes to a stop for any reason
.MC	BOOL	Set when the Find Home status indicates the operation has completed Cleared when a Find Home operation is started/restarted

Operation

Scan Mode	Description
Prescan	Initialize variables
Rung-condition-in is FALSE	Monitors for error conditions or changing of the drive mode
Rung-condition-in is TRUE	Updates the homing attributes in the drive with the specified values and starts the Find Home operation

Example 5: SM6_Set_Attribute2 - Set Attribute 1, Get Attribute 2

This example is used to set Attribute 1 and to get Attribute 2.



Description

Sets the value of the Attribute_ID_to_Set and monitors the value of the Attribute_ID_to_Get. The AOI will continue to monitor the Axis response while the IP flag is set, which allows the ladder logic to check for the value of the Attribute_ID_to_Get on another rung.

Operands

Operand	Data Type	Operand Type	Description
SM6_Set_Attribute	SM6_Set_Attribute	Tag	Control tag for this AOI
Axis	SM6_Axis	Tag	Targeted drive
RET	DINT	Output Value	Value of the attribute returned by the drive
Message_Type	SINT	Immediate Value	16#0000_001a - Position Controller Supervisor 16#0000_001b - Position Controller
Attribute_ID_to_Set	DINT	Immediate Value	ID of the attribute being set
Attribute_ID_to_Get	DINT	Immediate Value	ID of the attribute whose value is being monitored
Attribute_Value	DINT	Immediate Value	Requested value to which the attribute is being set

Structure

Field	Type	Description
.DN	BOOL	Set when the command is sent to the motor Cleared when instruction is not enabled or attribute ID is cleared
.IP	BOOL	Set when the response for the requested attribute ID is received Cleared when one of the input parameter values change, an error response is received, or the attribute id being returned is changed
.EQ	BOOL	Set when the value returned from the drive for the Attribute_ID_to_Get is equal to the Attribute_Value parameter Cleared when the attribute value returned by the motor is for a different attribute ID or does not match the Attribute_Value parameter Flag is only useful if the Attribute_ID_to_Set is the same as the Attribute_ID_to_Get
.ER	BOOL	Set when an error response is received from the motor Cleared when a Get Attribute operation is started or one of the input parameter values change

Operation

Scan Mode	Description
Prescan	Initialize variables and reset timeout
Rung-condition-in is FALSE	Monitor/update the Attribute_Value until the Attribute_ID_to_Get is cleared/changed.
Rung-condition-in is TRUE	Send a message to the drive to set the Attribute_ID_to_Set to Attribute_Value and monitor the value of the Attribute_ID_to_Get; the instruction will continue to monitor the Axis response and updates the RET value while the IP flag is set

Serial Port Homing (Class 6 Only)

The commands listed in the following table are used for homing operations through a serial port on the Moog Animatics SmartMotor. For details on the commands in the shaded rows, see the [SmartMotor™ Developer's Guide](#).

Command	Read Command	Description
MH	RMODE	Write/Read the Homing Mode
HM_VTZ=n	RHM_VTZ	Write/Read the Homing Velocity to Zero
HM_VTS=n	RHM_VTS	Write/Read the Homing Velocity to Switch
HM_ADT=n	RHM_ADT	Write/Read the Homing Accel/Decel
HM_OSET=n	RHM_OSET	Write/Read the Homing Offset
HM_MTHD=n	RHM_MTHD	Write/Read the Homing Method
	RCAN(2)	Read the CAN Control Word object (6040h) CAN(2)&272 extracts Homing bits
	RCAN(3)	Read the CAN Status Word object (6041h) CAN(3)&13312 extracts Homing bits
CANCTL(60,x), x=0,1	RCAN(60)	Write/read the Homing Invert flag: 0 - Active high 1 - Active low
CANCTL(61,x), x=0,1	RCAN(61)	Write/read the Homing style: 0-Animatics 1-CAN Interruptible
CANCTL(62,x), x=1,2	RCAN(62)	Write/read the CAN Halt Option code: 1 - Decelerate on the profile deceleration 2 - Slow down on Quick Stop deceleration
CANCTL(63,x)	RCAN(63)	Write/Read the CAN Quick Stop Deceleration value: 0-2147483647 (0h-7FFFFFFFh) Default: 7FFFFFFFh
CANCTL(68,x), x=0,1	RCAN(68)	Write/read the CAN Control Word Homing Start bit
CANCTL(69,x), x=0,1	RCAN(69)	Write/read the CAN Control Word Homing Halt bit
G		Start a homing operation
X		Halt a homing operation
S		Stop a homing operation
NOTE: All of these commands support Combitronic communications.		

Homing Command Usage

This section describes the steps for using the serial port homing commands.

1. Use the G, X and S commands
 - G - Starts the homing operation in both Homing styles
 - Clears and then Sets the CAN control word Homing Start bit
 - The firmware remembers that the homing operation was started from the G command so that the X and S commands will know to abort the homing operation
 - X - Halts the homing operation
 - Clears the CAN control word Homing Start bit
 - Animatics Style - halts the motor on the normal ramp; aborts the homing operation
 - CAN Interruptible Style- Interrupts the homing operation; halts the motor using the ramp specified by the CAN Halt Option code
 - S - Halts the homing operation
 - Animatics Style - (Sets the CAN control word HALT bit) Halts the motor on the Quick Stop Deceleration; aborts the homing operation
 - CAN Interruptible Style- Processed as a normal S command; the homing machine signals a Homing Error (CAN status word bit 13)
2. The following commands manipulate the CAN control word directly. The Homing machine will not clear these bits when the operation completes, so the user is responsible for resetting these flags when needed.
 - CANCTL(68,1) - Set the CAN control word Homing Start bit
 - Animatics Style - Starts a new homing operation when the Start bit transitions from 0 to 1
 - CAN Interruptible Style- Starts a new or Resumes an in-process homing operation when the Start bit transitions from 0 to 1
 - CANCTL(68,0) - Clear the CAN control word Homing Start bit
 - Animatics Style - halts the motor on the normal ramp; aborts the homing operation.
 - CAN Interruptible Style- Interrupts the homing operation, which stops at the end of the current segment using the normal ramp; it resumes from that point when the bit is set using the G command or the CANCTL(68,x) command
 - CANCTL(69,1) - Set the CAN control word Homing Halt bit
 - Animatics Style - Halts the motor; aborts the homing operation
 - CAN Interruptible Style- Starts a new or resumes an in-process homing operation when the Start bit transitions from 0 to 1
 - CANCTL(69,0) - Clear the CAN control word Homing Halt bit
 - Animatics Style - halts the motor on the normal ramp; aborts the homing operation
 - CAN Interruptible Style- Interrupts the homing operation at the end of the current segment using the normal ramp; it resumes from that point on a G command

Start a Homing Operation - G command

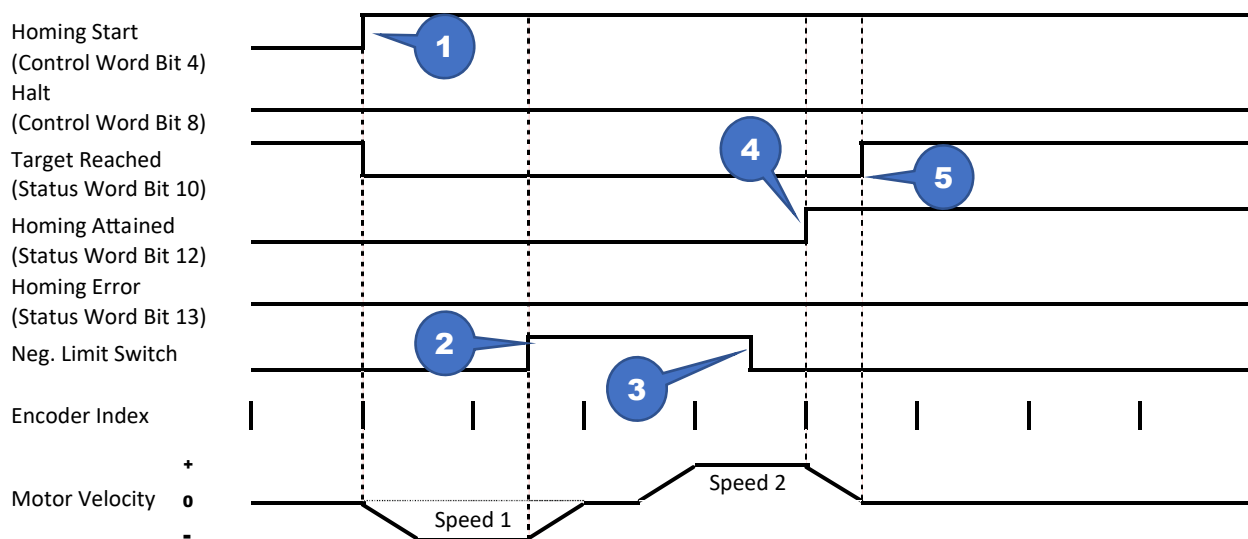
The G command starts the homing operation in both the Animatics and CAN Interruptible Homing styles using the following steps:

1. Clear the Homing CAN control word Homing Start bit if necessary.
2. Set the CAN control word Homing Start bit.

Assuming HM_MTHD is set to method 1 (homing on the negative limit switch):

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
0	0	0	0	1	Before the homing operation starts:
1	0	0	0	0	<ol style="list-style-type: none"> 1. A G command starts the operation. 2. The motor moves in the negative direction, at Homing Speed 1, until the negative limit switch is detected and then ramps to a stop. 3. The motor then moves in a positive direction, at Homing Speed 2, while looking for the negative limit switch to release and then for the next encoder index mark.
1	0	0	1	0	<ol style="list-style-type: none"> 4. The index mark is detected. <ul style="list-style-type: none"> • The home position is set to the encoder index position. • The zero position is calculated using the home position and home offset. • The motor begins ramping to a stop.
1	0	0	1	1	5. The motor comes to a halt; the homing operation is complete.

The event timing is as follows:

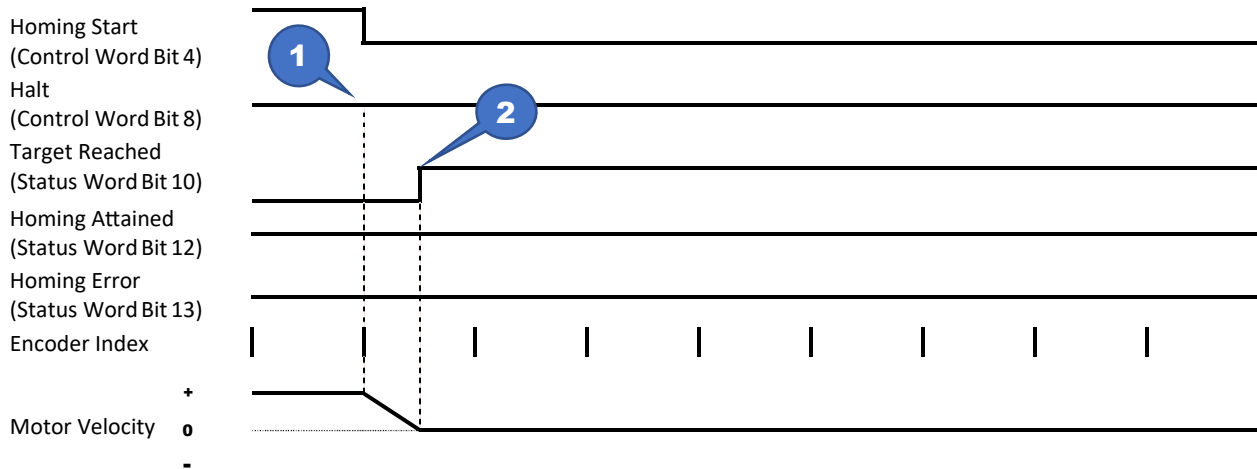


Halt a Homing Operation - X command (Animatics Style)

The following X-command procedure stops an in-progress Animatics Style homing operation. For information on halting a CAN Interruptible Style homing operation, see the next section.

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	0	0	0	0	A homing operation is in progress.
0	0	0	0	0	1. Issue an X command, the motor begins decelerating.
0	0	0	0	1	2. The motor comes to a halt; the motor velocity is zero.

The event timing is as follows:

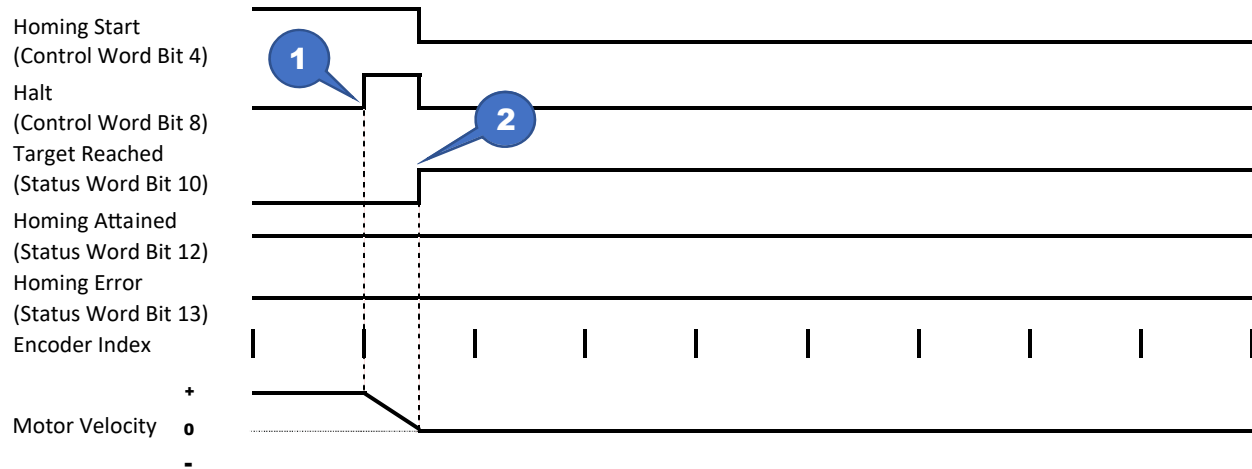


Halt a Homing Operation - X command (CAN Interruptible Style)

The following X-command procedure stops an in-progress CAN Interruptible Style homing operation. For information on halting an Animatics Style homing operation, see the previous section.

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	0	0	0	0	A homing operation is in progress.
1	1	0	0	0	1. Issue an X command, the motor begins decelerating.
0	0	0	0	1	2. The motor comes to a halt; the motor velocity is zero.

The event timing is as follows:

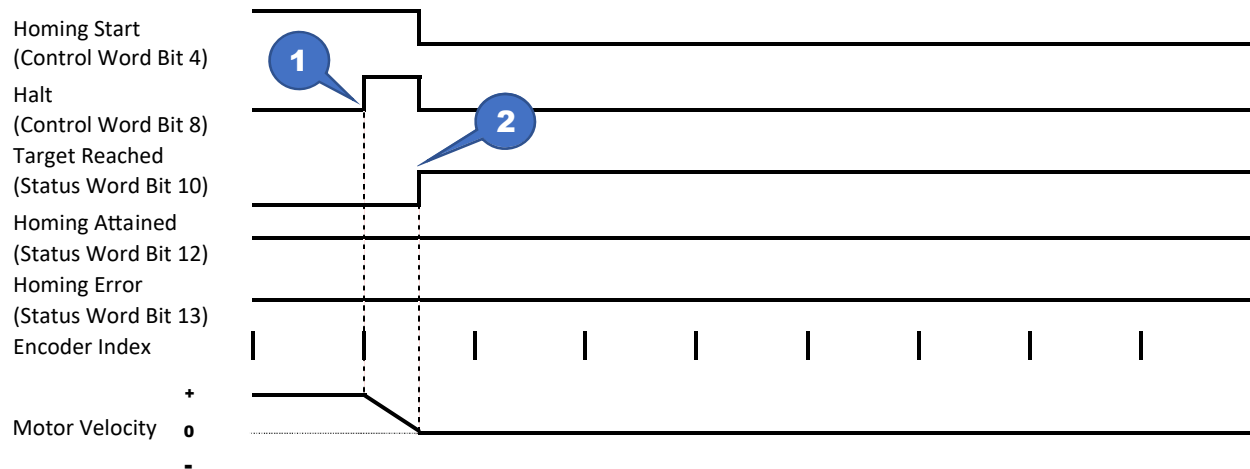


Halt a Homing Operation - S command (Animatics Style)

The following S-command procedure stops an in-progress Animatics Style homing operation. For information on halting a CAN Interruptible Style homing operation, see the next section.

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	0	0	0	0	A homing operation is in progress.
1	1	0	0	0	1. Issue an S command, the motor begins decelerating.
0	0	0	0	1	2. The motor comes to a halt; the motor velocity is zero.

The event timing is as follows:

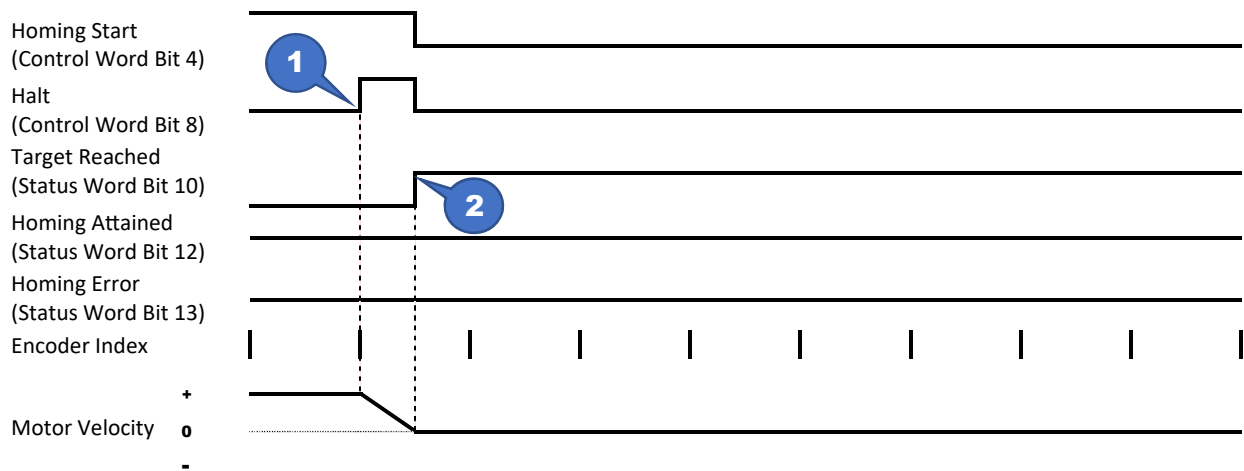


Halt a Homing Operation - S command (CAN Interruptible Style)

The following S-command procedure stops an in-progress CAN Interruptible Style homing operation. For information on halting an Animatics Style homing operation, see the previous section.

CAN Control Word		CAN Status Word			Description
Bit 4	Bit 8	Bit 13	Bit 12	Bit 10	
Homing Start	Halt	Homing Error	Homing Attained	Target Reached	
1	0	0	0	0	A homing operation is in progress.
1	0	0	0	0	1. Issue an S command, the motor begins decelerating.
0	0	1	0	1	2. The motor comes to a halt; the motor velocity is zero.

The event timing is as follows:



Example: AniBasic Serial Homing (Class 6 Only)

This user program will:

- Start a homing operation
- Display the CAN status word changes while waiting for the operation to complete
- Go to the zero position after the homing operation completes

```
#define HM_CANCTL_Statusword      3      'CANCTL homing index values
#define HM_CANCTL_HomingInvert    60     '
#define HM_CANCTL_HomingStyle     61     '
#define HM_CANCTL_HaltOption      62     '
#define HM_CANCTL_QSDecl          63     '
#define HM_CANCTL_HomingStart     68     '
#define HM_CANCTL_HomingHalt      69     '-----
#define HM_CANSTS_HomeError       8192   'CAN status word bit masks
#define HM_CANSTS_HomeAttained    4096   '
#define HM_CANSTS_HomeReached     1024   '
#define HM_CANSTS_HomeComplete    5120   '
#define HM_CANSTS_HomeInProgress  0      '-----
#define HM_CAN_STATUSBITS 13312        'Homing status word bits mask

' Set up the homing variables
HM_VTZ=20000
HM_VTS=40000
HM_ADT=21
HM_OSET=3000
HM_MTHD=1
CANCTL(HM_CANCTL_HomingStyle,0)      'Use Animatics Style homing

GOSUB2                                ' Do homing operation and wait for it to complete
MP PT=0 VT=50000 G TWAIT             ' Go to position zero
END

' Start homing operation
' Wait for homing operation to complete, displaying homing status word changes
C2
MH      ' Set motor to homing mode
G       ' Start the homing operation

' Wait for the homing operation to complete
s = HM_CANSTS_HomeInProgress
ss = HM_CANSTS_HomeReached
WHILE s != HM_CANSTS_HomeComplete | s!=ss
  ' Break from the loop if a homing error is detected
  IF s & HM_CANSTS_HomeError
    PRINT ("*")
    BREAK
  ENDIF

  ' Update the controller motor's homing status bit if changed
  IF (MODE==6 & s!=ss)
    'Display the homing status bit value
    GOSUB (9)

    ' Save the homing status bit value
```

```

        SS=S
    ENDIF

    ' Get the current CAN status word value,
    ' extract only the homing status bit values.
    s = CAN(HM_CANCTL_Statusword) & HM_CAN_STATUSBITS
    LOOP
    PRINT(#13)
RETURN

' Display the homing status bit value(s)
C9
    IF (s==0)
        a = HM_MTHD
        IF (CAN(HM_CANCTL_HomingStyle)==0)
            PRINT("Animatics: ",a," ")
        ELSE
            PRINT("Interruptible: ",a," ")
        ENDIF
    ENDIF
    PRINT(" s=",s," ")
    IF (s==0)
        PRINT("In-Progress")
    ELSE
        IF (s & HM_CANSTS_HomeError)
            PRINT("Error")
            ' Append a comma if more than one bit set
            IF (s != HM_CANSTS_HomeError) PRINT(",") ENDIF
        ENDIF
        IF (s & HM_CANSTS_HomeAttained)
            PRINT("Attained")
            ' Append a comma if HomeReached bit is set
            IF (s & HM_CANSTS_HomeReached) PRINT(",") ENDIF
        ENDIF
        IF (s & HM_CANSTS_HomeReached)
            PRINT("Reached")
        ENDIF
    ENDIF
    PRINT(" ")
RETURN

```

Using Mixed Mode Operations After Homing

There are applications where you may wish to use mixed modes of operation after homing. For example, you may want to use dual trajectory and gearing. In these cases, you need to ensure that the motor is at a known starting location. To accomplish that, issue the next command sequence after the homing operation.

```

' Issue these commands immediately after homing, while at position 0.
O=0      'Set the origin to 0
O(1)=0   'Set trajectory 1 to 0
PRT=0    'Set the relative target position to 0

```

That command sequence sets the applicable internal counters to zero, which ensures that counter values are as expected for mixed mode operations.

Revision History

March 2022

- Initial release

TAKE A CLOSER LOOK

Moog Animatics, a sub-brand of Moog Inc. since 2011, is a global leader in integrated automation solutions. With over 30 years of experience in the motion control industry, the company has U.S. operations and international offices in Germany and Japan as well as a network of Automation Solution Providers worldwide.

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