

Application Guide

# VLT® Integrated Motion Controller 48.XX





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# 1 Before you begin

## 1.1 Introduction to the Application Guide

This chapter describes the purpose of the application guide, manual version, intended audience, disclaimer, safety conventions, and additional resources.

## 1.2 Purpose of this Application Guide

This application guide provides information about recommended parameter settings and descriptions to operate drives in applications which use Integrated Motion Controller (IMC) on the VLT® AutomationDrive FC 302 series.

Installation and operating instructions are not in scope of the application guide.

## 1.3 Intended Audience

The intended audience of the application guide is trained personnel, automation engineers, and programmers with experience in operating with parameters and with basic knowledge of DanfossAC drives.

## 1.4 Manual Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this manual is in English.

Manual Version	Remarks	Software Version
MG375	First version	48.XX

## 1.5 Additional Resources

Additional resources are available with related information.

The programming guide provides information on all the parameters in Danfoss.

The design guide provides information about the capability and functionality to design motor control systems.

The operating guide provides detailed specification, requirements, and installation instructions of the FC 302.

Technical documentation for various product options is available via the [Danfoss home page](#) in the Service and Support/ Documentation section.

### Safety Symbols

The following symbols are used in this manual:

 <b>DANGER</b> 
Indicates a hazardous situation when not avoided, results in death or serious injury.

**⚠ WARNING ⚠**

Indicates a hazardous situation when not avoided, could result in death or serious injury.

**⚠ CAUTION ⚠**

Indicates a hazardous situation when not avoided, could result in minor or moderate injury.

**NOTICE**

Indicates information considered important, but not hazard-related (for example, messages relating to property damage).

## 1.6 Disclaimer

This publication contains information proprietary to Danfoss. By accepting and using this manual, the user agrees that the information contained in this guide is used solely for operating equipment from Danfoss, or equipment from other vendors if such equipment is intended for communication with Danfoss equipment over a serial communication link. This publication is protected under the Copyright laws of Denmark and most other countries.

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## 2 Introduction to IMC

### 2.1 An Overview to IMC

The Integrated Motion Controller (IMC) enables position control with all control principles and motor types with and without feedback for the VLT.

IMC enables the following functions:

- Positioning
- Synchronization
- Homing
- Virtual Master

Position control in both positioning and synchronization modes can be either sensorless or with feedback.

In the sensorless control principle, the motor angle calculated by the motor controller is used as feedback. In the closed loop control principle, VLT® AutomationDrive FC 302 supports 24 V encoders as standard. With extra options, the drive supports most standard incremental and absolute encoders, and resolvers. The position controller can handle both linear and rotary systems. The controller can scale positions to any relevant physical unit such as mm or °.

To activate IMC, select [9] *Positioning* or [10] *Synchronization* in parameter 1-00 Configuration Mode.

### 2.2 Software version and Control Card

Software version 48.33 and higher can only be installed on control card MK II. The white USB port identifies a control card MK II.

To order VLT® AutomationDrive FC 302 drives with the IMC software, select S067 as Software Release in position 24-27 of the type code. For more information on ordering the software, see Design Guide.

### 2.3 Reference Handling

IMC can be used in positioning and synchronization applications without more options.

#### Positioning

Reference for the target position depends on any of the following positioning types:

- **Absolute:** Target position relates to the defined zero point of the machine.
- **Relative:** Target position relates to the actual position of the machine.
- **Touch Probe:** Target position relates to a signal on a digital input.

Position control can be sensorless or with feedback. For sensorless control, the motor angle calculated by the motor controller is used as feedback. In closed-loop (with feedback) control principle, 24 V encoders are the standard option. With extra options, incremental encoders, absolute encoders, and resolvers are supported.

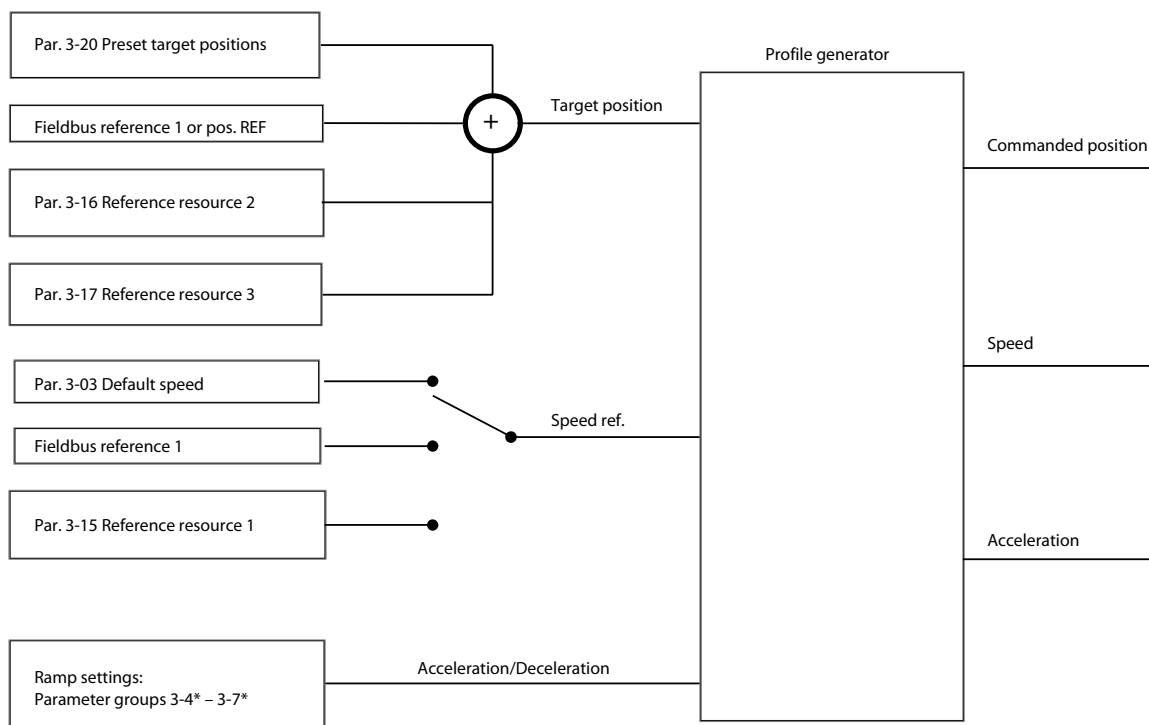
The position controller can handle both linear and rotary systems. Position values are scaled to relevant physical units. All positioning and synchronization are controlled either by digital I/O or fieldbus.

A positioning command requires 3 inputs:

- Target position
- Speed reference
- Ramp times



These 3 inputs can come from various sources as shown in the illustration.



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Illustration 1: Positioning References

### Synchronization

During synchronization, a master encoder signal is sent to the drive which is followed by the motor based on scaling. The following synchronization features are available:

- Synchronize multiple shafts to the same encoder signal.
- Option to use different scaling on each shaft, as required.
- Synchronize to a real master.
- Synchronize to a virtual master.

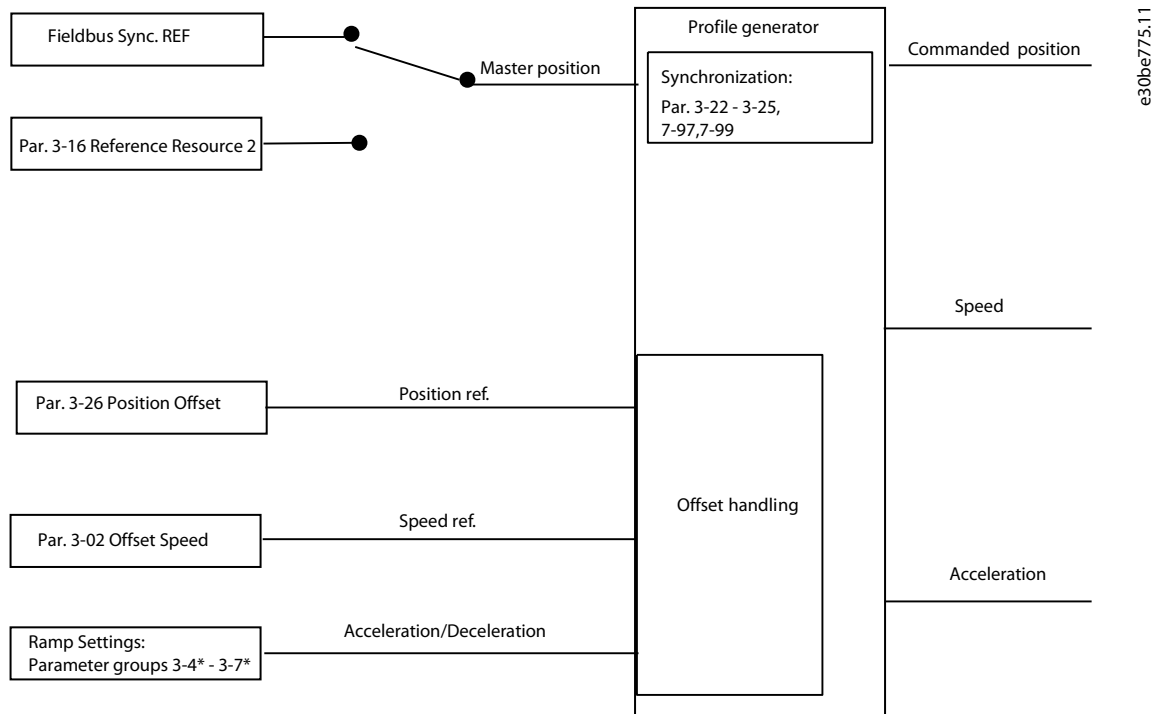


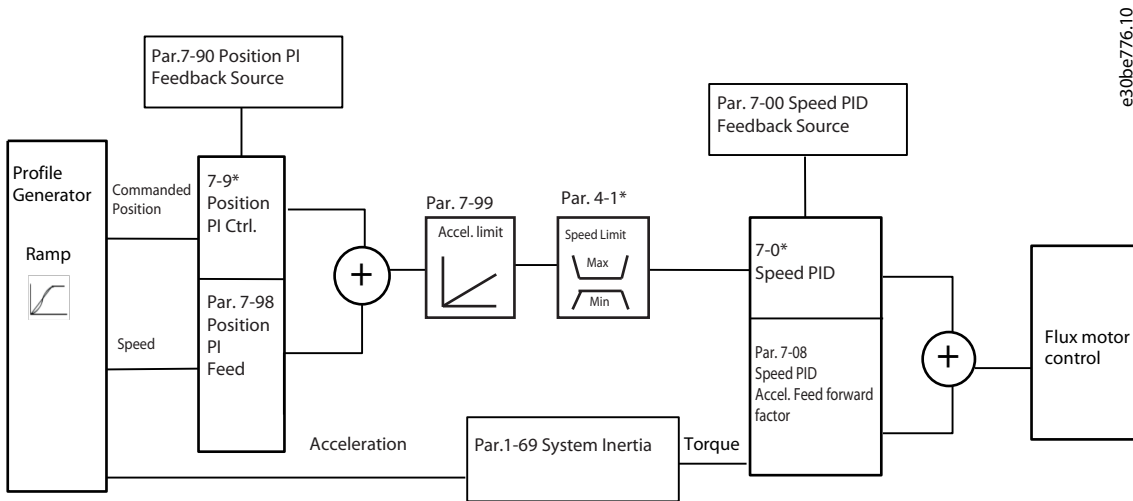
Illustration 2: Synchronization References

For positioning and synchronizing, in each control cycle (1 ms), the profile generator calculates position, speed, and acceleration required to do a specific movement. The outputs from the profile generator are used as inputs for the position and speed controller as described in [2.4 Control Loops and Control Configurations](#).

## 2.4 Control Loops and Control Configurations

In positioning and synchronization mode, the position PI controller is added as an outer loop providing the speed reference for the speed PID.

The illustration below shows the control structure and parameters affecting the control behavior with flux motor control.



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Illustration 3: Positioning and Synchronization Mode

## 2.5 Control Configurations

IMC supports multiple types of configurations for motor, speed, and position control with or without feedback and allows adaptation to most applications.

It is possible for one or more controllers to be active depending on the basic configuration in *parameter 1-01 Motor Control Principle*.

- **U/F and VVC<sup>+</sup>:** Position PI controller (*parameter group 7-9\* Position PI Ctrl*)
- **Flux sensorless and Flux with motor feedback:** Speed PID controller (*parameter group 7-0\* Speed PID Ctrl*) and Position PI controller (*parameter group 7-9\* Position PI Ctrl*).

With sensorless control, the estimated rotor position is used as feedback for motor, speed, and position control.

Motor and speed control uses the same feedback whereas the position controller can use the same or a different feedback.

The following control configurations are possible:

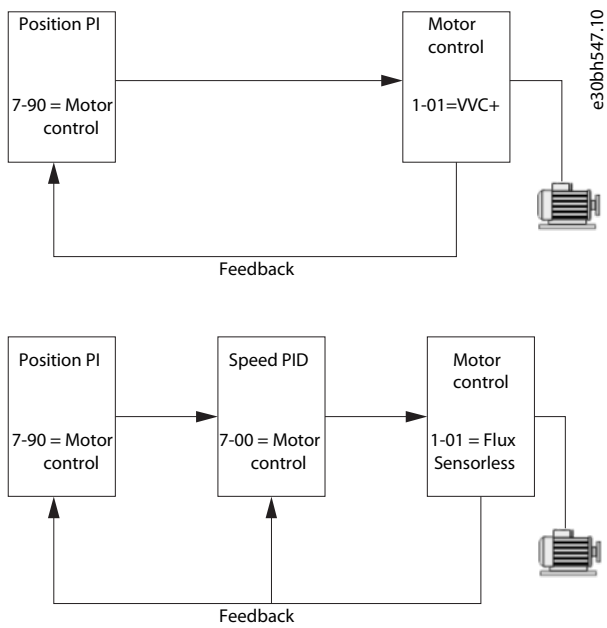


Illustration 4: Sensorless Motor/Speed/Position Control, VVC+ or Flux Sensorless

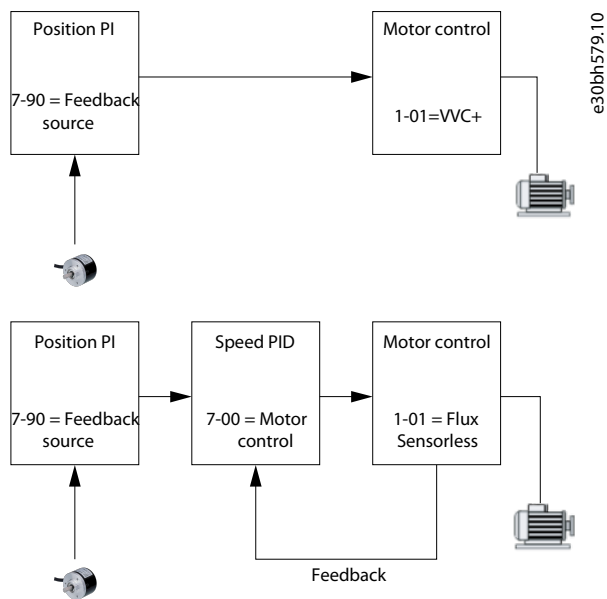


Illustration 5: Sensorless Motor/Speed Control and Position Control with Feedback, VVC+ or Flux Sensorless

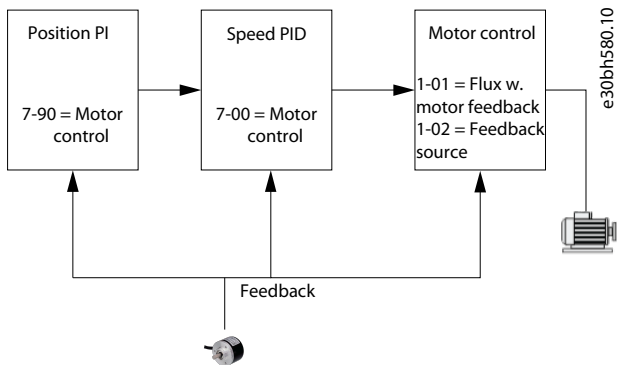


Illustration 6: Motor/Speed/Position Control with Motor Feedback, Flux with Motor Feedback

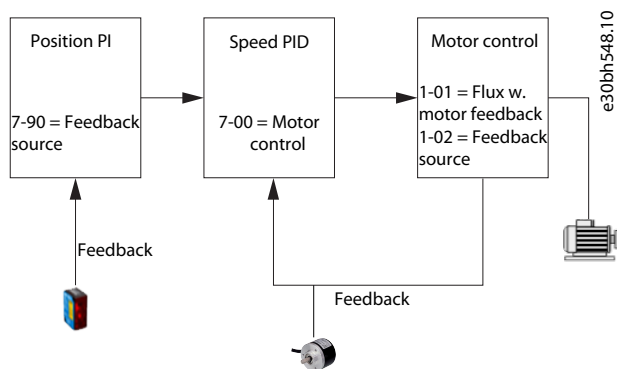


Illustration 7: Motor/Speed/Position control with Motor Feedback and position control with Application Feedback, Flux with Motor Feedback

## 2.6 Control and Status Signals

IMC control and status signals are available as digital I/O bits and fieldbus bits. The following table details the available options.

**Table 1: Control Signals**

Name	Function	Digital Input <sup>1)</sup>	Control Word
Enable master offset	Activates the master offset when <i>parameter 17-93 Master Offset Selection</i> is set to options [0]–[5].	✓	✓
Start homing	Starts selected homing function.	✓	✓
Enable virtual master	Starts the virtual master	✓	✓
Activate touch	Selects touch probe positioning mode.	✓	✓
Relative position	Selects between absolute and relative positioning.	✓	✓
Enable reference	Starts selected motion.	✓	✓
Sync. to position mode	Selects positioning in synchronizing mode.	✓	✓
Home sensor	Selects input for home sensor.	✓	✓
Home sensor inverse	Selects input for home sensor.	✓	-
Touch sensor	Selects input for touch probe sensor.	✓	✓
Touch sensor inverse	Selects input for touch probe sensor.	✓	-
Speed mode	Selects speed mode when <i>parameter 1-00 Configuration Mode</i> is set to [9] <i>Positioning</i> or [10] <i>Synchronization</i> .	✓	✓
Target inverse	Changes the sign of the set target position. For example, if the set target is 1000, the activation of this option changes the value to -1000.	✓	✓

When [3] *FC Motion Profile* is selected in *parameter 8-10 Control Word Profile*, the bits in the control word have the following meaning:

Bit	0	1
0	Preset Reference LSB	-
1	Preset reference MSB	-
2 <sup>1)</sup>	Preset reference EXB	-
3	Coast stop	No coast stop
4	Quick stop	No quick stop
5	No reference	Enable reference
6	Ramp stop	Start
7	No reset	Reset
8	No jog	Jog
9 <sup>1)</sup>	Absolute	Relative
10	Data not valid	Data valid
11 <sup>1)</sup>	No homing	Start homing
12 <sup>1)</sup>	No touch	Activate touch
13	Setup select LSB	-
14	Setup select MSB	-
15	No reversing	Reversing

1) Different from [0] FC Profile.

Options for bit 0–2 and 12–15 in parameter 8-14 Configurable Control Word CTW:

- [11] Start Homing
- [12] Activate Touch Probe
- [13] Sync. to Pos. Mode
- [14] Ramp 2
- [15] Relay 1
- [16] Relay 2
- [17] Speed Mode
- [18] Enable Virtual Master
- [19] Activate Master Offset
- [20] Target Inverse
- [26] Home Sensor
- [27] Touch Sensor

**Table 2: Status Signals**

Name	Function	Digital Output	Status Word
Reverse after ramp	Indicates the sign of speed reference after the ramp	✓	-
Virtual master dir.	Controls the direction of followers.	✓	-
Homing OK	Homing is completed with the selected homing function.	✓	✓
On target	Positioning: Target position reached. Synchronization: Follower position aligned with master position.	✓	✓
Position error	Maximum position error exceeded.	✓	✓
Position limit	A position limit is reached ( <i>parameter 3-06 Minimum Position or parameter 3-07 Maximum Position</i> ).	✓	✓
Touch on target	Target position is reached in touch probe position mode.	✓	✓
Touch activated	Touch probe positioning active.	✓	✓

When [3] *FC Motion Profile* is selected in *parameter 8-10 Control Word Profile*, the bits in the status word have the following meaning:

Bit	0	1
0	Control not ready	Control ready
1	Frequency converter not ready	Frequency converter ready
2	Coasting	Enable
3	No error	Trip
4 <sup>1</sup>	Not homed	Home done
5	Reserved	Reserved
6	No error	Trip lock
7	No warning	Warning
8 <sup>1</sup>	Not on target position	Target position reached
9	Local operation	Bus control
10	Out of frequency limit	Frequency limit OK
11	No operation	In operation
12	Frequency converter OK	Stopped, auto start
13	Voltage OK	Voltage exceeded
14	Torque OK	Torque exceeded
15	Timer OK	Timer exceeded

1) Different from [0] *FC Profile*.



Options for bits 5 and 12–15 in *parameter 8-13 Configurable Status Word STW*:

- [4] Position Error
- [5] Position Limit
- [6] Touch on Target
- [7] Touch Activated

## 2.7 Homing

Homing is required for creating a reference to the physical machine position in closed-loop control principle with incremental encoder or in sensorless control principle.

IMC supports various homing functions with or without a homing sensor. Select the homing function in *parameter 17-80 Homing Function*. After selecting a homing function, complete homing before executing absolute positioning.

### 2.7.1 Home Position

At this position, there is no movement. The current position of the physical machine is defined as Home Position. The actual position *Parameter 16-06 Actual Position* is set to the value of *parameter 17-82.0 Home Position*

### 2.7.2 Analog Input

When there is no movement, the position value which corresponds to the actual value on the analog input is set as actual position.

Example:

- *Parameter 3-06 Minimum Position* = 0
- *Parameter 3-07 Maximum Position* = 1000
- Analog input = 5 V

Actual position is set to 500.

### 2.7.3 Direction with Home Sensor

Search for home sensor is started in forward or reverse direction. The reversing signal controls the search using the speed set in *parameter 17-83 Homing Speed*.

When the home sensor is detected, the position of the physical machine at the leading edge of the home sensor signal is defined as home position. The value in *parameter 16-06 Actual Position* is set to the value of *parameter 17-82.0 Home Position* index 0 when running forward or *parameter 17-82.1 Home Position* index 1 when running reverse.

The drive stops at the set home position.

The following illustration shows scenarios with different starting point.

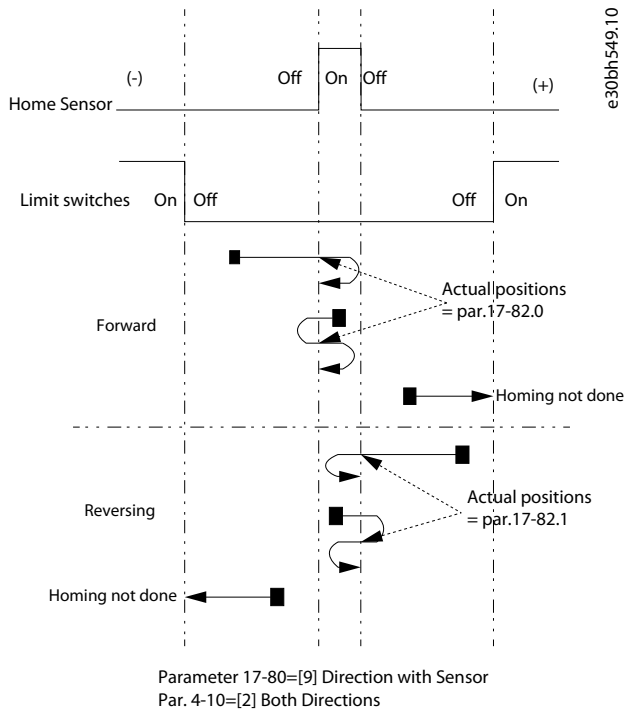


Illustration 8: Direction with Sensor

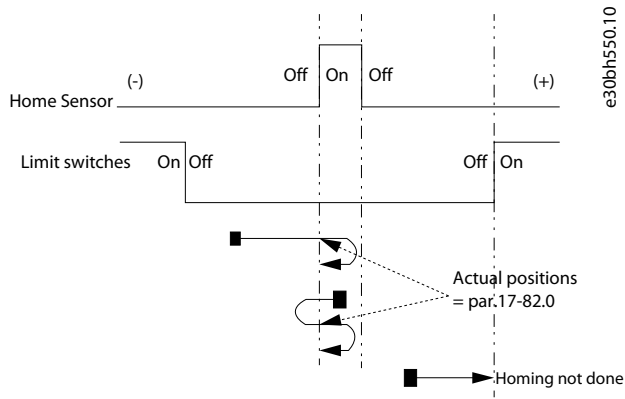
### 2.7.4 Forward or Reverse with Home Sensor

Search for the home sensor is started in the selected direction using the speed set in *parameter 17-83 Homing Speed*.

When the home sensor is found, the position of the physical machine at the leading edge of the home sensor signal is defined as home position. The *parameter 16-06 Actual Position* is set to the value of *parameter 17-82.0 Home Position index 0*.

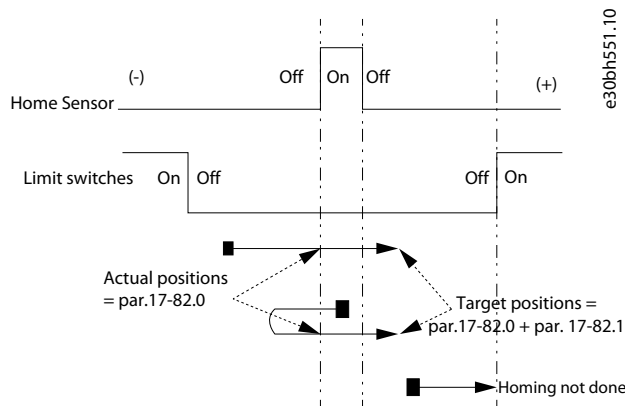
The drive then stops at the home position in *parameter 17-82.0 Home Position index 0* and the offset set position in *parameter 17-82.1 Home Position index 1*.

The following illustration shows possible scenarios with different starting points.



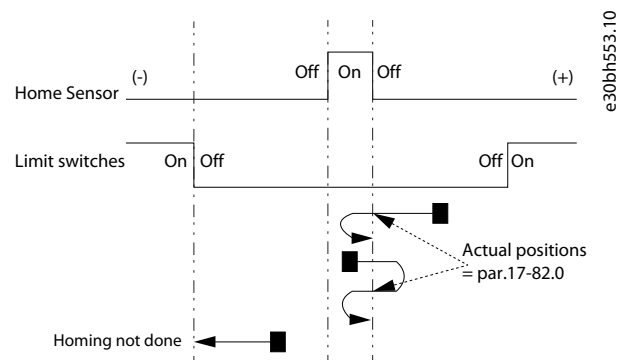
Parameter 17-80=[10] Forward with Sensor  
 Par. 4-10=[2] Both Directions, par. 17-82.1=0

Illustration 9: Forward with Home Sensor - *Parameter 17-82.1 = 0*



Parameter 17-80=[10] Forward with Sensor  
 Par. 4-10=[2] Both Directions, par. 17-82.1>0

Illustration 10: Forward with Home Sensor - *Parameter 17-82.1 > 0*



Parameter 17-80=[11] Reverse with Sensor  
 Par. 4-10=[2] Both Directions par. 17-82.1=0

Illustration 11: Reverse with Home Sensor - *parameter 17-82=0*

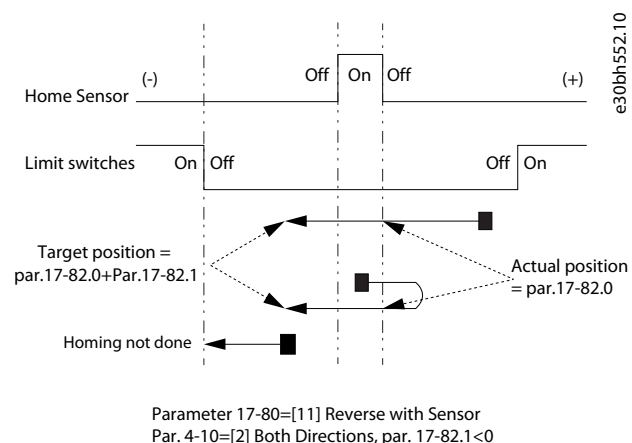


Illustration 12: Reverse with Sensor - parameter 17-82.1 < 0

### 2.7.5 Forward or Reverse II with Home Sensor

The same functionality as forward or reverse with home sensor, with two more functions:

- Search for the home sensor with the speed set in *parameter 17-83 Homing Speed*. When the home sensor is detected, the actual homing is done with 10% of the homing speed. This technique enables searching for the home sensor at a high speed without reducing the homing accuracy.
- When an end limit switch is found before the home sensor is detected, the drive reverses and searches for the home sensor in the opposite direction. Based on the setting in *parameter 4-75 Start Fwd/Rev Function*, the drive shows a warning or alarm 215, Start Fwd/Rev, when both the end limits are found without detecting the home sensor.

The following graphical representations show scenarios with different starting positions.

The black line show running at homing speed and the red line show running at 10% of the homing speed.

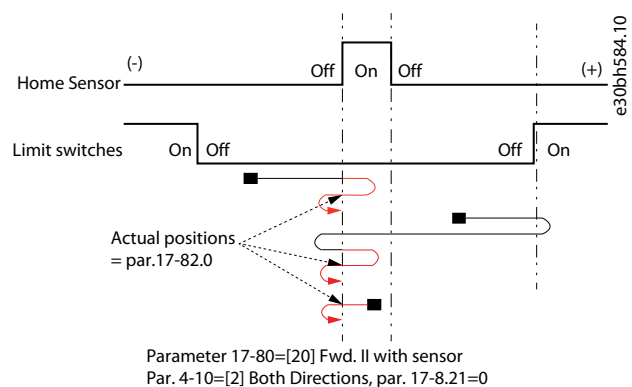


Illustration 13: Forward II with Sensor, Parameter 17-82.1 = 0

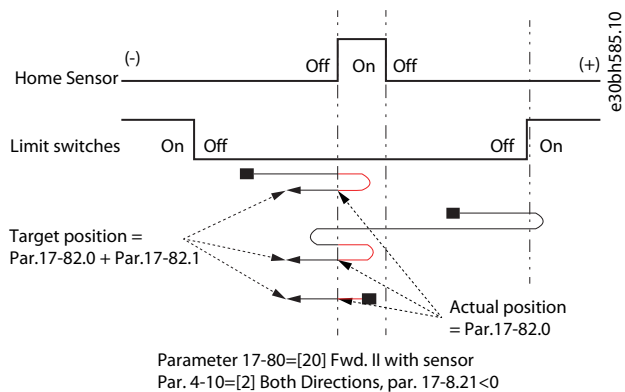


Illustration 14: Forward II with Sensor, *Parameter 17-82.1 < 0*

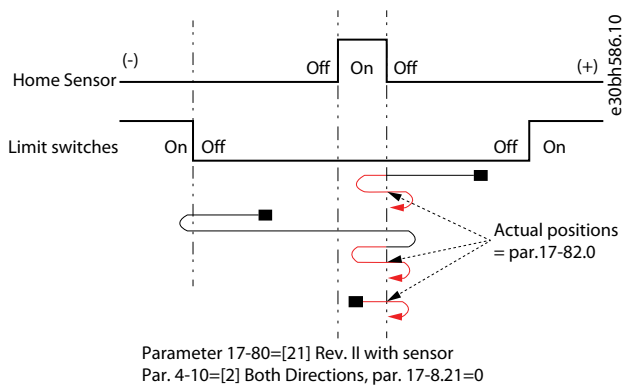


Illustration 15: Reverse II with Sensor, *Parameter 17-82.1 = 0*

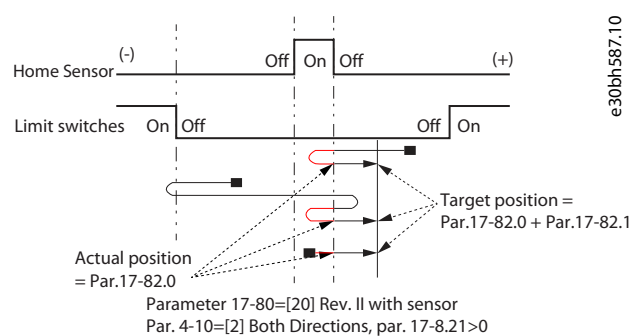


Illustration 16: Reverse II with Sensor, *Parameter 17-82.1 > 0*

## 2.7.6 Direction with Encoder Zero Pulse

Search for zero pulse is started in forward or reverse direction. The reversing signal controls the search using the speed set in *parameter 17-83 Homing Speed*.

When the zero pulse is detected, the physical position of the machine at the zero pulse signal is defined as Home position.

The actual position *parameter 16-06 Actual Position* is set to *parameter 17-82.0 Home Position* index 0 when running forward or *parameter 17-82.1 Home Position* index 1 when running reverse.

The drive stops at the set home position.

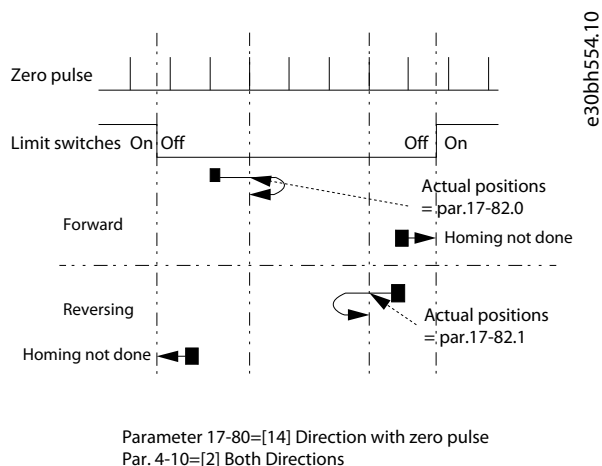


Illustration 17: Direction with Encoder Zero Pulse

### 2.7.7 Forward or Reverse with Encoder Zero Pulse

The search for zero pulse begins in the selected direction using the speed set in *parameter 17-83 Homing Speed*.

When the zero pulse is detected, the physical position of the machine at the zero pulse signal is defined as home position. *Parameter 16-06 Actual Position* is set to the value in *parameter 17-82.0 Home Position* index 0.

The drive stops at the home position.

Home position is the value in *parameter 17-82.0* + the offset value in *parameter 17-82.1*.

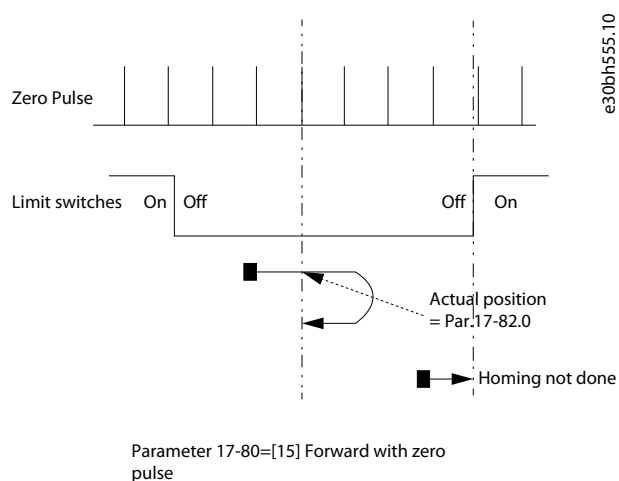


Illustration 18: Forward with Encoder Zero Pulse - *Parameter 17-82.1 = 0*

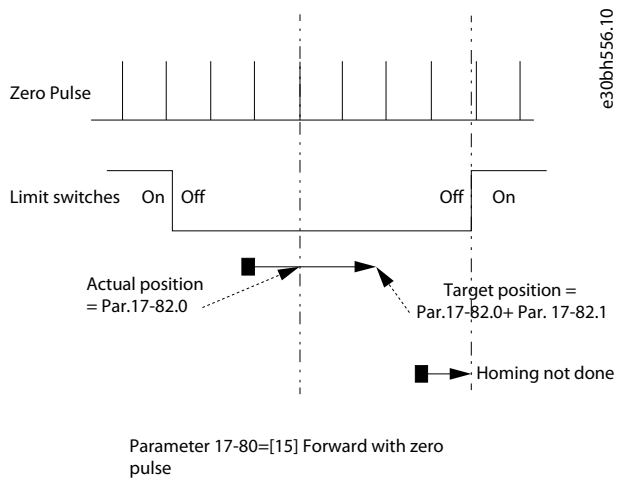


Illustration 19: Forward with Encoder Zero Pulse - *Parameter 17-82.1 > 0*

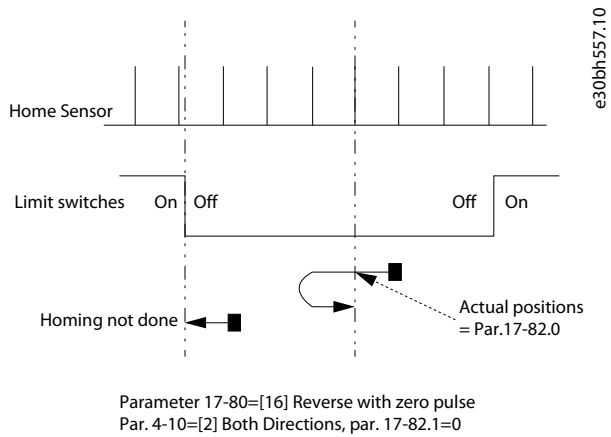


Illustration 20: Reverse with Zero Pulse - *Parameter 17-82.1 = 0*

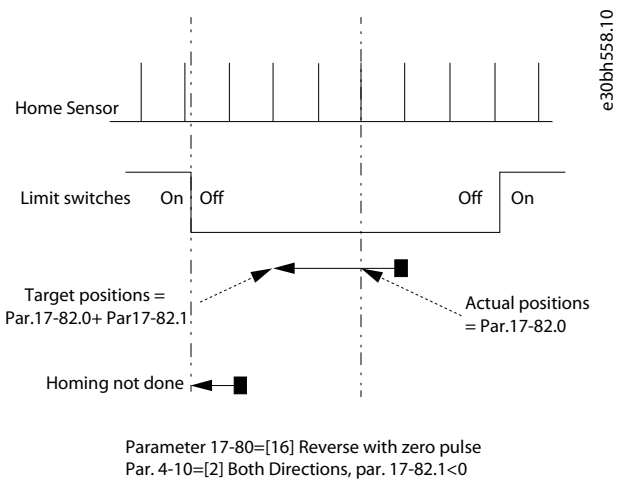


Illustration 21: Reverse with Zero Pulse - *Parameter 17-82.1 < 0*

### 2.7.8 Direction with Home Sensor and Encoder Zero Pulse

The search for home sensor starts by using the speed set in *parameter 17-83 Homing Speed*. After finding the home sensor, the drive continues in the same direction.

The position of the physical machine at the next zero pulse signal is defined as home position. When in forward direction, *parameter 16-06 Actual Position* is set to the value of *parameter 17-82.0 Home Position* index 0 and when in reverse, *parameter 16-06 Actual Position* is set to the value in *parameter 17-82.1 Home Position* index 1.

The drive then stops at the set home position.

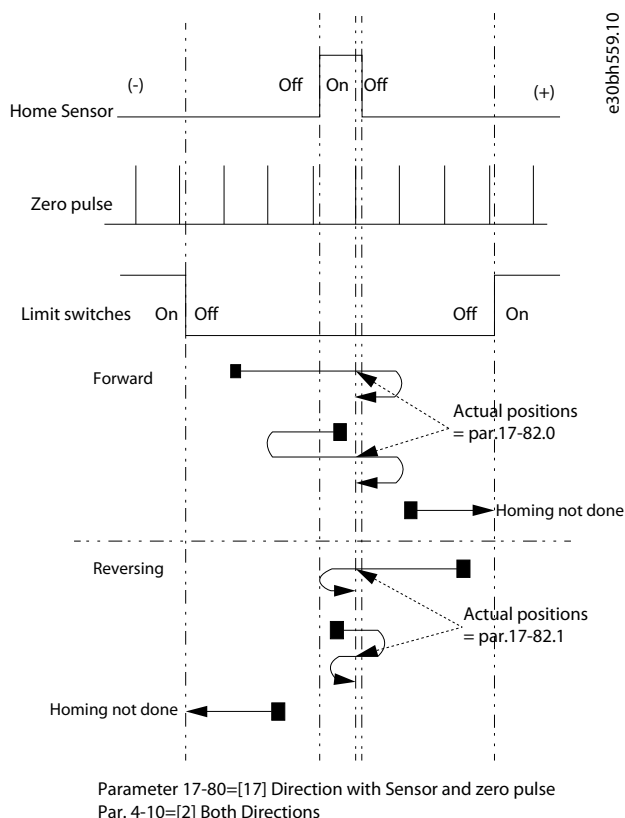


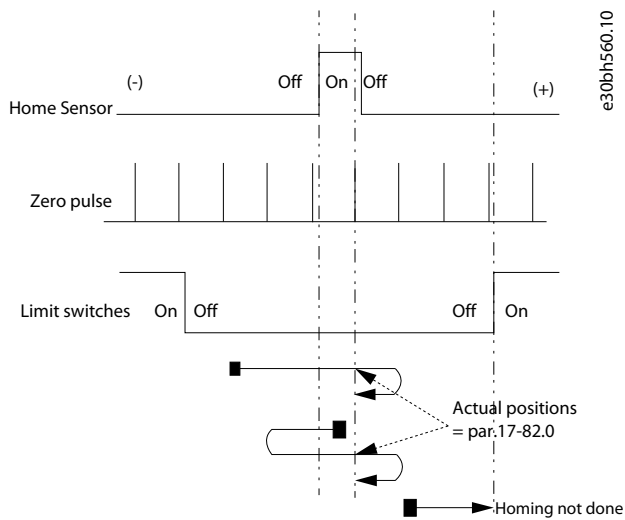
Illustration 22: Direction with Home Sensor and Encoder Zero Pulse

### 2.7.9 Forward or Reverse with Home Sensor and Encoder Zero Pulse

Home sensor search is started in the selected direction with the speed set in *parameter 17-83 Homing Speed*. On detecting the home sensor, the drive continues in the same direction and the physical position of the machine at the next zero pulse signal is defined as Home Position. The actual position *parameter 16-06 Actual Position* is set to the value of *parameter 17-82.0 Home Position* index 0.

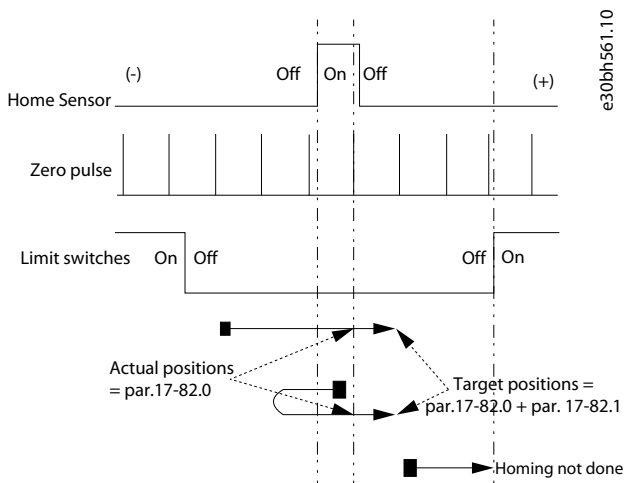
The drive stops at the home position *parameter 17-82.0 Home Position* index 0) + the offset set in *parameter 17-82.1 Home Position* index 1.





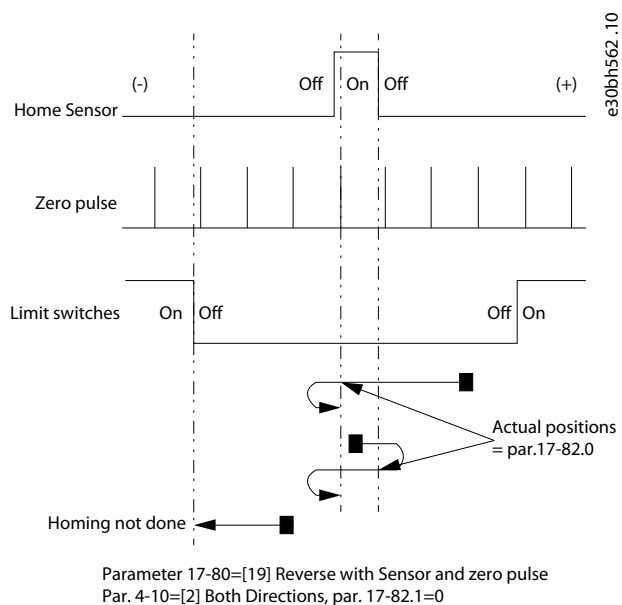
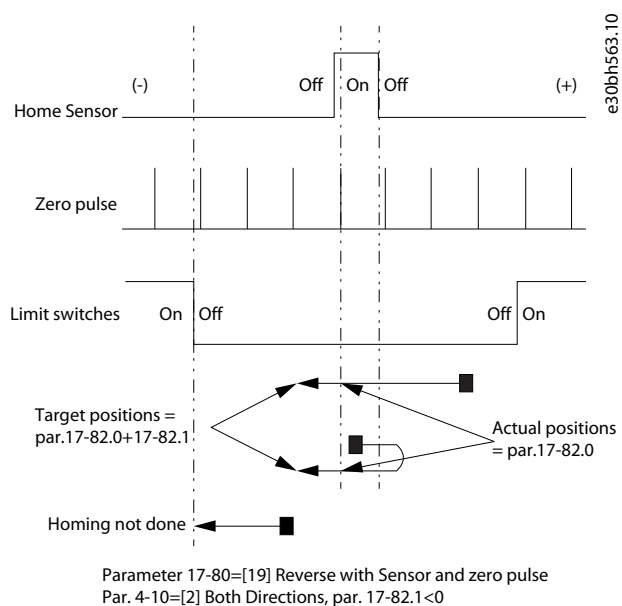
Parameter 17-80=[18] Forward with Sensor and zero pulse  
 Par. 4-10=[2] Both Directions, par. 17-82.1=0

**Illustration 23: Forward with Home Sensor - Parameter 17-82.1 = 0**



Parameter 17-80=[18] Forward with Sensor and zero pulse  
 Par. 4-10=[2] Both Directions, par. 17-82.1>0

**Illustration 24: Forward with Home Sensor - Parameter 17-82.1 > 0**


**Illustration 25: Reverse with Home Sensor - Parameter 17-82.1 = 0**

**Illustration 26: Reverse with Home Sensor - Parameter 17-82.1 < 0**

## 2.7.10 Torque Limit

Using the speed set in *parameter 17-83 Homing Speed*, the search for home sensor begins in the selected direction. The position of the physical machine where the motor is forced to stop on reaching the homing Torque Limit is defined as Home Position. The homing torque limit is set in *parameter 17-84 Homing Torque Limit*.

Actual Position is set to the value specified in *parameter 17-82.0 Home Position* index 0. The drive then goes to the home position.

Home position is the value in *parameter 17-82.0* + the offset set in *parameter 17-82.1 Home Position* index 1. See [2.7.1 Home Position](#).

### 2.7.11 Home Synchronization

When Home Synchronization is active, the actual position is reset when passing the home sensor in forward or reverse direction.

In forward direction, the actual position is set to *parameter 17-82.0 Home Position* index 0.

In reverse direction, the actual position is set to *parameter 17-82.1 Home Position* index 1 at the leading edge of the home sensor signal.

Condition for resetting actual position when Home Synchronization is active can be selected in *parameter 17-81 Home Sync Function*.

## 2.8 Recommendations for Commissioning Steps

### Procedure

1. Configure the LCP status screen.
2. Perform motor configuration.
3. Configure feedback for closed loops.
4. Configure speed PID and position PI.

Default settings available in the AC drives are suitable for most applications.

5. Scale position units and scale master for synchronizing the gear ratio.
6. Configure homing.

This configuration is only relevant for absolute positioning in sensorless or closed loop with incremental encoder.

7. Configure control signals and references.

### 3 Setups and Connection Examples for Positioning and Synchronizing

#### 3.1 Linear Sensorless Positioning

The following setup shows an application which utilizes sensorless control of a PM motor without encoder feedback.

- Absolute positioning with 2 fixed targets selected by PROFIBUS or Digital I/O.
- Position reference after power-up is created by homing on a physical sensor.
- Hardware end limits.
- Position values are scaled to mm units.
- Application is moving at 37 mm per motor revolution.

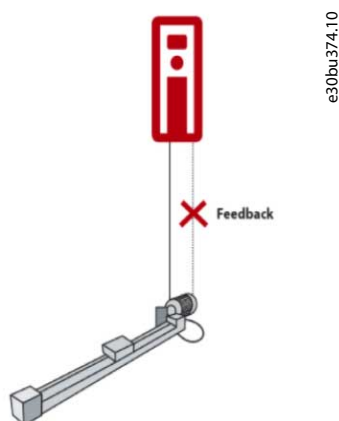


Illustration 27: Linear Sensorless Positioning

##### 3.1.1 Control by Digital I/O

Following are the recommended parameter settings when absolute positioning with 2 fixed targets is controlled by digital I/O.

Table 3: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[9] Positioning	Enables position control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-06 Minimum position	-100 mm	Defines the safe area of movement. The setting of this parameter depends on physical machine layout.
3-07 Maximum position	500 mm	Defines the safe area of movement. The values depend on the layout of the physical machine.
3-20.0 Preset target	-50 mm	First fixed target.
3-20.1 Preset target	450 mm	Second fixed target.
3-41 Ramp 1 ramp up time	2 s	Used to calculate the speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	Used to calculate the speed profile for positioning.
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.

Parameter number and name	Setting for the application	Description of the setting
4-74 Start Fwd/Rev function	[8] Coast & Trip	Set the function when hardware end limits are activated to coast and trip (alarm). The alarm must be reset before movement can be resumed. Reset is only possible via LCP as all inputs are used.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes the motor and starts movement towards selected target.
5-12 Terminal 27 Digital input	[16] Preset ref bit 0	Use input 27 to select between the 2 preset targets.
5-13 Terminal 29 Digital input	[110] Start homing	Use input 29 to start the home function.
5-14 Terminal 32 Digital input	[12] Enable start forward	Use inputs 32 and 33 as hardware end limits.
5-15 Terminal 33 Digital input	[13] Enable start reverse	
5-40.0 Function relay	[223] On target	Use relay 1 to signal that target position is reached.
5-40.1 Function relay	[222] Homing ok	Use relay 2 to signal that home function is completed.
17-70 Position unit	2 mm	Select mm as position unit in LCP.
17-72 Position unit numerator	37	Defines distance of movement per motor revolution.
17-73 Position unit denominator	1	
17-80 Homing function	[11] Reverse with sensor	Performs a search for the homing sensor in reverse direction.
17-83 Homing speed	100 RPM	The speed required for homing.
17-92 Position control selection	[2] Enable reference	The enable reference mode is selected permanently. Extra signal is not required to enable new target position. Drive moves to a new target when it is selected while in run mode (start).

### 3.1.1.1 Connections

The following connection shows linear sensorless positioning when sensor homing and end limits are controlled by digital I/O.

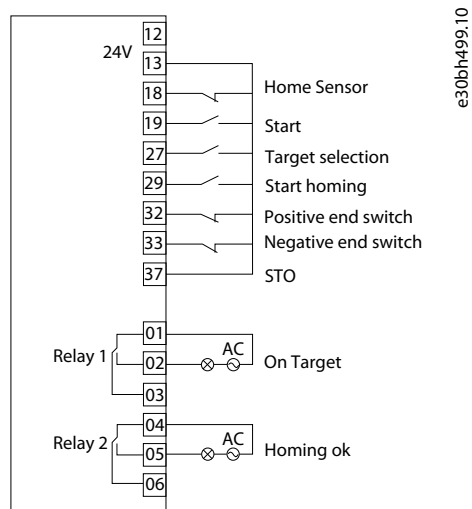


Illustration 28: Linear Positioning - Control by Digital I/O

### 3.1.2 Control by Fieldbus

Following are the recommended parameter settings when absolute positioning with 2 fixed targets is selected by PROFIBUS.

Table 4: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[9] Positioning	Enables position control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-06 Minimum position	-100 mm	Defines the safe area of movement. The setting of this parameter depends on the physical machine layout.
3-07 Maximum position	500 mm	
3-41 Ramp 1 ramp up time	2 s	Used to calculate the speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-14 Terminal 32 Digital input	[12] Enable start forward	Use inputs 32 and 33 as hardware end limits.
5-15 Terminal 33 Digital input	[13] Enable start reverse	
4-74 Start Fwd/Rev function	[8] Coast & Trip	Set the function when hardware end limits are activated to coast and trip (alarm). Make sure to reset before movement can be resumed. Reset is possible only via LCP as all inputs are used.
8-01 Control Site	[2] Control Word only	Select option for control is via fieldbus.
9-15.2 PCD Write Configuration	[1683] Fieldbus Pos. REF	Use PCD 2 and 3 as 32-bit target position, PCD 1 is speed reference.

Parameter number and name	Setting for the application	Description of the setting
9-16.2 PCD Read Configuration	[1606] Actual position	Use PCD 2 and 3 to read the actual position as a 32-bit value.
9-16.3 PCD Read Configuration	[1606] Actual position	
17-70 Position unit	[2] mm	Select mm as position unit in LCP.
17-72 Position unit numerator	37	Defines the distance of movement per motor revolution.
17-73 Position unit denominator	1	
17-80 Homing function	[11] Reverse with sensor	Performs a search for the homing sensor in reverse direction.
17-83 Homing speed	100 RPM	The speed required for homing.

### 3.1.2.1 Connections

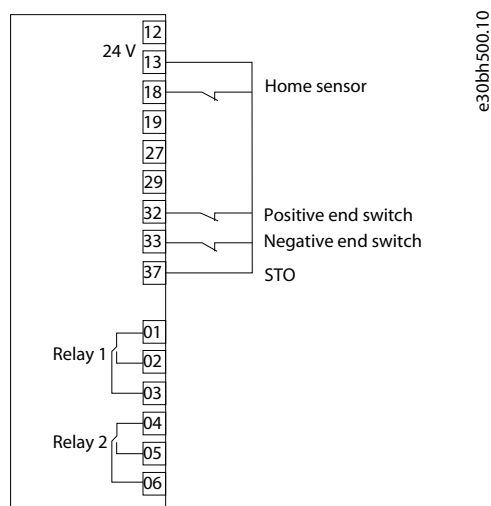


Illustration 29: Linear Positioning - Fieldbus

### 3.1.2.2 Control Word Examples

Following are the control word and status word examples applicable for linear sensorless positioning when controlled by fieldbus.

Table 5: Control Word

Function	Binary	Hexadecimal	Comment
Start homing (bit 11)	0000 1100 0001 1000	0C18	Homing is also possible with active start signal (0C58).
Start (bit 6)	0000 0100 0101 1000	0458	Magnetizes motor maintaining current position.
Enable reference (bit 5)	0000 0100 0111 1000	0478	Activates set target position and starts movement.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start and/or enable reference signals such as 04F8.

### 3.1.2.3 Fieldbus Data Layout

The following illustrations describe the fieldbus data layout when writing to the drive and reading from the drive.

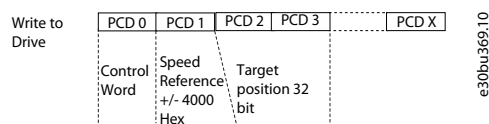


Illustration 30: Data Layout - Write to Drive

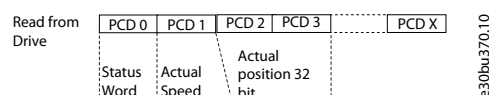


Illustration 31: Data Layout - Read from Drive

### 3.1.2.4 Status Word Examples

Following are the status word and status word examples applicable for linear sensorless positioning when controlled by fieldbus.

Table 6: Status Word

Function	Binary	Hexadecimal	Comment
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0111 0001 1000	0718	Drives has stopped with an Alarm, alarm type and status can be read in parameters 16-9x.
Homing done (bit 4)	0000 1111 0001 0111	0F17	The selected homing function has been completed.
Target reached (bit 8)	0000 1111 0001 0111	0F17	The active target position has been reached within <i>parameter 3-08 On Target Window</i> .

## 3.2 Rotary Positioning

Consider an indexing table with 8 stations, used by an application with rotary positioning:

- Relative positioning of 45 degrees.
- Sensorless control of induction motor with gearbox 6.14:1.
- Homing is performed on the fly.
- Position values scaled to degrees.
- Control, status, and target position communicated via PROFIBUS or digital I/O.



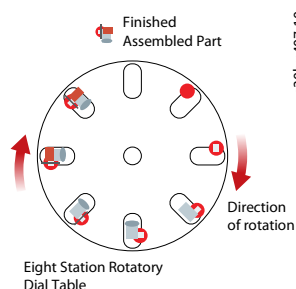


Illustration 32: Rotary Positioning

### 3.2.1 Control by Digital I/O

Following are the recommended parameter settings for the application when controlled by digital I/O.

Table 7: Parameter Settings and Descriptions

Parameter number and name	Setting for the applicaton	Description of the setting
1-00 Configuration Mode	[9] Positioning	Enables position control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-03 Maximum reference	Set required positioning speed.	The setting is used to calculate speed profile for positioning. The setting can also be set by external signal or preset reference <i>parameter 3-10 Preset Reference</i> .
3-06 Minimum Position	0°	The minimum and maximum positions defines 1 revolution in rotary mode.
3-07 Maximum position	360°	
3-20.0 Preset target	45°	Target position
3-41 Ramp 1 ramp up time	2 s	Used to calculate the speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor and maintains current position.
5-13 Terminal 29 Digital input	[113] Enable reference	The drive moves the distance set in <i>parameter 3-20 Preset Target</i> at each positive edge on terminal 29.
5-40.0 Function Relay	[223] On target	Use relay 1 to signal that the target position is reached.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor and starts movement towards selected target.

Parameter number and name	Setting for the applicaton	Description of the setting
5-13 Terminal 29 Digital input	[110] Start homing	Use input 29 to start the home function.
5-40.0 Function relay	[223] On target	Use relay 1 to signal when target position has reached
17-70 Position unit	4°	Use degrees as position unit in LCP.
17-72 Position unit numerator	2520	Defines the distance of movement per motor revolution. The gearbox is 43/7 to 1 (6.14 is a rounded value. Using 6.14 means the position drifts over time).  Numerator is 360 x 7 considering 360° per revolution.  Denominator is 43.
17-73 Position unit denominator	43	
17-76 Position Axis mode	[1] Rotary 0 - Max	Rotary axis, actual position counting between 0 and value of <i>parameter 3-07 Maximum Position</i> .
17-80 Homing function	[2] Home Sync Function	The actual position is set to the value defined by <i>parameter 17-82</i> when home sensor is activated.
17-81 Home Sync function	[6] Every time	Defines that home position is aligned every time the home sensor is passed.
17-82.0 Home Position	[Sensor Position]	Set the position of the home sensor when approached in forward direction. Use <i>parameter 17-82.1 Home Position</i> to define the position of the home sensor when approached in reverse direction, if relevant.
17-92 Position control selection	[1] Relative Position	Select relative positioning.  When set to [0] No Operation by default, absolute positioning is enabled.  Switch between absolute and relative positioning using digital input, when necessary.

### 3.2.1.1 Connections

The illustration shows connection for rotary positioning when controlled by digital I/O.

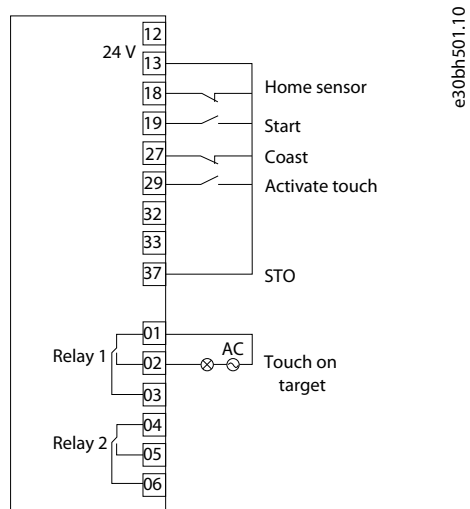


Illustration 33: Rotary Positioning - Digital I/O Control

### 3.2.2 Control by Fieldbus

Following is the recommended parameter settings for the application when control is led via fieldbus.

Table 8: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[9] Positioning	Enables position control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-06 Minimum position	0°	Defines 1 revolution in rotary mode.
3-07 Maximum position	360°	
3-41 Ramp 1 ramp up time	2 s	Used to calculate the speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. the option sets low signal with active sensor.
8-01 Control site	[2] Control word only	Control via fieldbus control word only, no need for digital inputs.
9-15.2 PCD Write Configuration	[1683] Fieldbus Pos. REF	Use PCD 2 and 3 as 32-bit target position, PCD 1 is speed reference.
9-15.3 PCD Write Configuration	[1683] Start	

Parameter number and name	Setting for the application	Description of the setting
9-16.2 PCD Read Configuration	[1606] Actual position	Use PCD 2 and 3 to read the actual position as a 32-bit value.
9-16.3 PCD Read Configuration	[1606] Actual position	
17-70 Position unit	[4]°	Use degrees as position unit in LCP.
17-72 Position unit numerator	2520	Defines distance of movement per motor revolution. The gearbox is 43/7 to 1 (Using 6.14 is a rounded value which means that the position drifts over time) and there is 360° per revolution so numerator is 360 x 7 and denominator is 43.
17-73 Position unit denominator	43	
17-76 Position Axis mode	[1] Rotary 0 - Max	Rotary axis, actual position counting between 0 and value of parameter 3-07 Maximum Position.
17-80 Homing function	[2] Home Sync Function	Actual position is set to the value defined by parameter 17-82 Home Position when home sensor is activated.
17-81 Home Sync Function	[6] Every time	Defines that home position is aligned every time the home sensor is passed.
17-82.0 Home position	[Sensor position]	Set the position of the home sensor when approached in forward direction.  Use parameter 17-82.1 Home Position to define position of home sensor when approached in reverse direction if relevant.
17-92 Position Control Selection	[1] Relative Position	Selects relative positioning.  If set to [0] No Operation, absolute positioning is default and it is possible to switch between absolute and relative positioning by digital input.

### 3.2.2.1 Connections

The illustration shows rotary positioning when controlled by fieldbus.

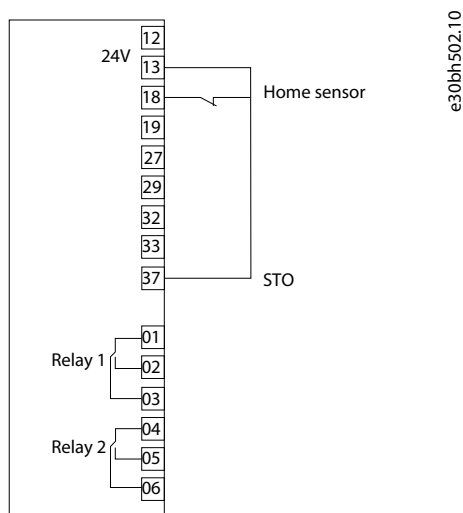


Illustration 34: Rotary Positioning - Fieldbus Control

### 3.2.2.2 Control Word Examples

Function	Binary	Hexadecimal	Description
Start (bit 6)	0000 0100 0101 1000	0458	Magnetizes the motor while maintaining current position.
Enable reference (bit 5)	0000 0100 0111 1000	0478	The drive moves the distance set by target position (PCD 2 and 3) at each change of bit 5 from 0 to 1.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start and/or enabling reference signals such as 04F8.

### 3.2.2.3 Status Word Examples

Function	Binary	Hexadecimal	Description
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0110 0000 1000	0608	Drives has stopped with an Alarm, alarm type and status can be read in parameters 16-9x.
Target reached (bit 8)	0000 1111 0001 0111	0F17	The active target position has been reached within <i>parameter 3-08 On Target Window</i> .

### 3.2.2.4 Fieldbus Data Layout

The following illustrations describe the fieldbus data layout when writing to the drive and reading from the drive.

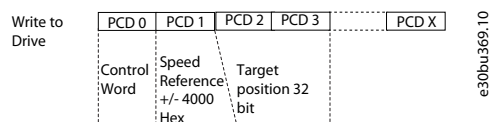


Illustration 35: Data Layout - Write to Drive

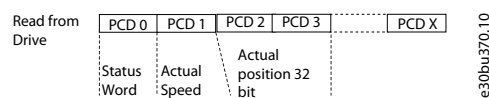


Illustration 36: Data Layout - Read from Drive

## 3.3 Touch Probe Positioning

This application uses a roller conveyer for positioning of pallets using touch probe positioning, based on the following:

- Sensor signal.
- Sensorless control of PM motor.
- Movement of pallet by 29.33 mm per motor revolution, which is determined from drive train and roller diameter.
- Control, status, and touch target position by digital I/O or PROFIBUS (fieldbus).

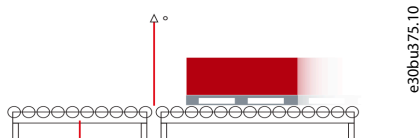


Illustration 37: Touch Probe Positioning

### 3.3.1 Control by Digital I/O

Following are the recommended parameter settings for Touch Probe Positioning when the control is via Digital I/O.

Table 9: Parameter Settings and Descriptions

Parameter number and name	Setting for the applicaton	Description of the setting
1-00 Configuration Mode	[0] Speed open loop	Speed control until touch probe sensor is found.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-10.0 Preset reference	50%	Preset reference for speed and positioning mode. Reference can also be an external signal such as analog input 53.
3-21 Touch target	500 mm	Set distance between touch sensor and required stop position.
3-41 Ramp 1 ramp up time	2 s	Ramps used to calculate speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[118] Touch sensor inverse	Use input 18 as touch sensor input. The option sets low signal with active sensor.
5-11 Terminal 18 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor and starts movement towards selected target.
5-13 Terminal 29 Digital input	[111] Activate touch	Input 29 activates monitoring of touch sensor while running in speed mode. When touch sensor is detected the drive changes to position control and sets target as the sum of position of the touch sensor and the value of parameter 3-21 Touch Target. After reaching the target input 29 must be set low to re-start running in speed mode.
5-40.0 Function relay	[226] Touch on target	Use relay 1 to signal touch probe target position reached.
17-70 Position unit	[2] mm	Use mm as position unit in LCP.
17-72 Position unit numerator	293	Defines distance of movement per motor revolution.
17-73 Position unit denominator	10	

### 3.3.1.1 Connections

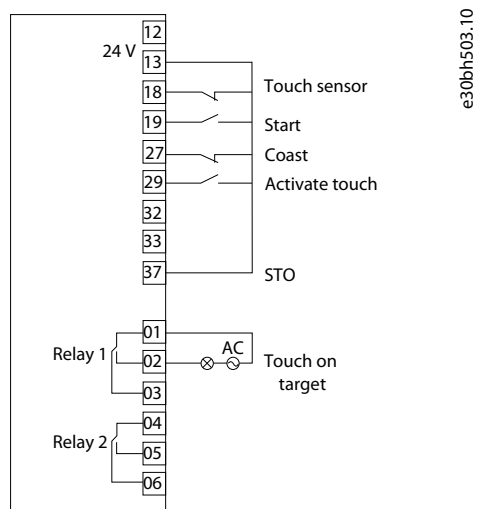


Illustration 38: Touch Probe Positioning - Digital I/O Control

### 3.3.2 Control by Fieldbus

Following are the recommended parameter settings for touch probe positioning when control is via fieldbus (PROFIBUS).

Table 10: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[0] Speed open loop	Set open-loop speed control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-10.0 Preset reference	50%	Preset reference for speed and positioning. Also, the reference can be an external signal, such as analog input 53.
3-07 Maximum position	360°	
3-41 Ramp 1 ramp up time	2 s	Ramps used to calculate the speed profile for positioning.
3-42 Ramp 1 ramp down time	2 s	
8-01 Control site	[2] Control word only	Control signals via fieldbus control word.
8-13.15 Configurable Status Word	[226] Touch on target	Use bit 15 to signal when the stop position is reached.
8-14.12 Configurable Status Word	[12] Activate touch	Bit 12 activates touch sensor search.
9-15.2 PCD Write Configuration	[321] Touch Target	Use PCD 2 to set the stop position. The maximum position value is 360. Hence, a single PCD, which is 16 bit, is sufficient.
9-16.2 PCD Read Configuration	[321] Touch target	Use PCD 2 and PCD 3 to set parameter 3-21 Touch Target, PCD 1 is speed reference.
9-16.3 PCD Write Configuration	[321] Touch target	
17-70 Position unit	[2] mm	Use ° (degrees) as position unit in LCP.
17-72 Position unit numerator	36	Defines the distance of movement per motor revolution.
17-73 Position unit denominator	1	

### 3.3.2.1 Connections

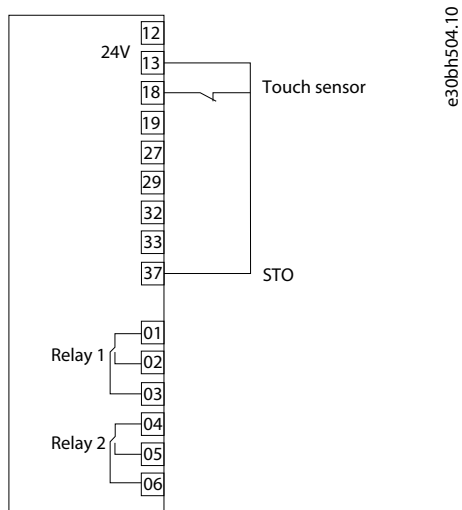


Illustration 39: Touch Probe Positioning - Control by Fieldbus

### 3.3.2.2 Control Word Examples

Function	Binary	Hexadecimal	Description
Start (bit 6)	0000 0100 0101 1000	0458	Magnetizes the motor maintaining the current position.
Speed Mode (bit 13)	0010 0100 0101 1000	2478	The drive runs in speed control with reference set by PCD 1.
Activate touch (bit 12)	0011 0100 0101 1000	3478	Activates touch mode monitoring touch sensor input, when touch sensor is detected drive will move distance defined by PCD 2 and 3.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start, speed mode and touch signals, for example: 34D8

### 3.3.2.3 Status Word Examples

Function	Binary	Hexadecimal	Description
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0110 0000 1000	0608	Drives has stopped with an Alarm, alarm type and status can be read in parameters 16-9x.
Target reached (bit 8)	0000 1111 0001 0111	0F17	The active target position has been reached within <i>parameter 3-08 On Target Window</i> .

### 3.3.2.4 Fieldbus Data Layout

The following illustrations describe the fieldbus position data layout for touch probe positioning when writing to the drive and reading from the drive.



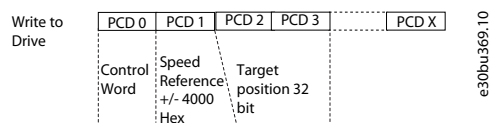


Illustration 40: Data Layout - Write to Drive

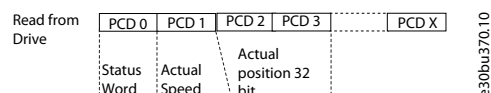


Illustration 41: Data Layout - Read from Drive

### 3.4 Position Stop

Consider a rotating machine in an application which uses position stop, with the following specifications:

- Speed controlled PM Motor without feedback.
- Machine stop at 90°.
- Position scaled for 0-360°.
- 10 motor revolutions per machine cycle.
- Homing on sensor.
- Control by digital I/O input (analog) or fieldbus (PROFIBUS).

#### 3.4.1 Control by Digital I/O

Following are the recommended parameter settings when the control is via digital I/O.

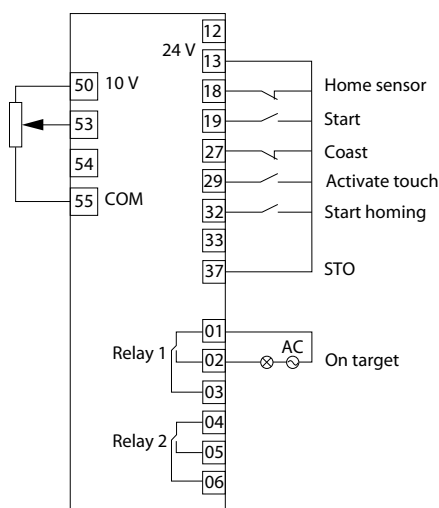
Table 11: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[0] Speed Open Loop	Open-loop speed control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-06 Minimum position	0°	Defines 1 revolution in rotary mode.
3-07 Maximum position	360°	
3-21 Touch target	90°	Stop position.
3-41 Ramp 1 ramp-up time	2 s	Used for start or stop in speed mode and to calculate speed profile.
3-42 Ramp 1 ramp-down time	2 s	
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor and runs with the reference set by analog input 53.

Parameter number and name	Setting for the application	Description of the setting
5-13 Terminal 29 Digital input	[111] Activate Touch	High signal activates positioning to target set by <i>parameter 3-21 Touch Target</i> . Low signal speed control with the set reference is resumed.
5-14 Terminal 32 Digital input	[110] Start Homing	Use input 32 to start the home function.
5-40.0 Function relay	[223] On target	Use relay 1 to signal target position reached.
17-70 Position unit	[4]°	Use ° as position unit in LCP.
17-72 Position unit numerator	36	Defines the distance of movement per motor revolution. 1 motor revolution is 1/10th of machine revolution, hence 36° per motor revolution.
17-73 Position unit denominator	1	
17-76 Position Axis mode	[1] Rotary 0 - Max	Rotary axis, actual position counting between 0 and value of <i>parameter 3-07</i> .
17-80 Homing function	[10] Forward with sensor	The drive moves forward at homing speed set in <i>parameter 17-83 Homing Speed</i> until home sensor is activated. The actual position is set to value to <i>parameter 17-82.0 Home Position</i> .
17-82.0 Home Position	Sensor position	The actual position of the home sensor is set.

### 3.4.1.1 Connections

The illustration depicts connection for position stop when controlled by digital I/O.



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Illustration 42: Position stop - Digital I/O Control

### 3.4.2 Control by Fieldbus

Following are the parameter recommendations for the application when control by PROFIBUS.

**Table 12: Parameter Settings and Descriptions**

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration mode	[0] Speed Open Loop	Open-loop speed control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-06 Minimum position	0°	Defines 1 revolution in rotary mode.
3-07 Maximum position	360°	
3-41 Master scale numerator	2 s	Used for start/stop in speed mode and to calculate speed profile for positioning.
3-42 Master scale denominator	2 s	
4-10 Motor speed direction	[2] Both directions	Enables movement in both directions.
5-10 Terminal 18 Digital input	[116] Home Sensor Inverse	Use input 18 as Home sensor input. The option sets low signal with active sensor.
8-01 Control site	[2] Control word only	Control via fieldbus control word only, no need for digital inputs.
8-13.15 Configurable Status Word STW	[6] Touch on target	Use bit 15 to signal that stop position is reached.
8-14.12 Configurable Control Word CTW	[12] Activate touch	1 activates positioning to target set by <i>parameter 3-21 Touch Target</i> . 0 re-activates speed control with the set reference.
9-15.2 PCD Write Configuration	[321] Touch target	Use PCD 2 to set stop position, max position value is 360 so 1 PCD (16 bit) is sufficient.
9-16.2 PCD Read Configuration	[1608] Position Error	Use PCD 2 and 3 to read position error as a 32-bit value.
17-70 Position unit	[4]°	Select ° (degree) as position unit using the LCP.
17-72 Position unit numerator	36	Defines distance of movement per motor revolution. 1 motor revolution is 1/10th of machine revolution hence 36° per motor revolution.
17-76 Position Axis mode	1	
17-80 Home Function	[10] Forward with Sensor	The drive moves forward at Homing speed <i>parameter 17-83 Homing Speed</i> until home sensor is activated. The actual position is set to value to <i>parameter 17-82.0 Home Position</i> .
17-82.0 Home Position	Sensor position	Actual position of the home sensor is set.

### 3.4.2.1 Connections

The illustration shows position stop when controlled by fieldbus.

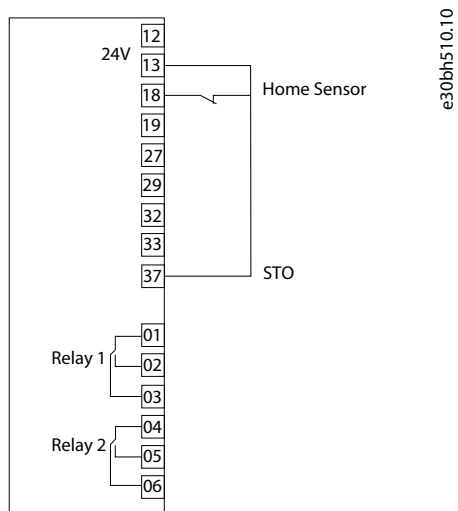


Illustration 43: Position stop - Fieldbus Control

### 3.4.2.2 Control Word Examples

Function	Binary	Hexadecimal	Description
Start homing (bit 11)	0000 1100 0001 1000	0C18	Homing is also possible with active start signal (0C58).
Speed mode (bit 0)	0010 0100 0001 1001	0411	Change from position to speed mode.
Start (bit 6)	0000 0100 0101 1001	0458	Starts running at speed reference.
Activate touch (bit 1)	0000 0100 0101 1011	045A	Activates position stop to set stop position.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start, speed mode, and touch signals (04BA).

### 3.4.2.3 Status Word Examples

Function	Binary	Hexadecimal	Description
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0110 0000 1000	060B	Drives has stopped with an Alarm, alarm type and status can be read in parameters 16-9x.
Homing done (bit 4)	0000 1110 0001 0111	0E17	The selected homing function has been completed.
Touch on target (bit 5)	0000 1111 0001 0111	0EA7	The active target position has been reached within <i>parameter 3-08 On Target Window</i> .

### 3.4.2.4 Fieldbus Data Layout

The following illustrations describe the fieldbus position data layout for touch probe positioning when writing to the drive and reading from the drive.

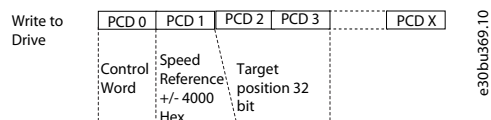


Illustration 44: Data Layout - Write to Drive

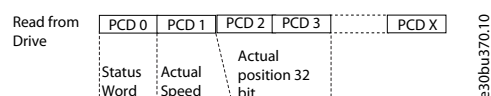


Illustration 45: Data Layout - Read from Drive

## 3.5 Synchronizing with External Master

The following image shows an application which utilizes a vertical conveyor belt. The vertical conveyor belt is synchronized with the horizontal conveyor for transfer of boxes.

- Master signal from HTL encoder on horizontal conveyor.
- Vertical conveyor is driven by PM motor in sensor less control.
- Homing on sensor to get correct alignment before starting synchronization.
- Determination of gear ratio from the physical setup as the slot length is different. The follower must make 1 rotation when master makes 1.5 rotations.

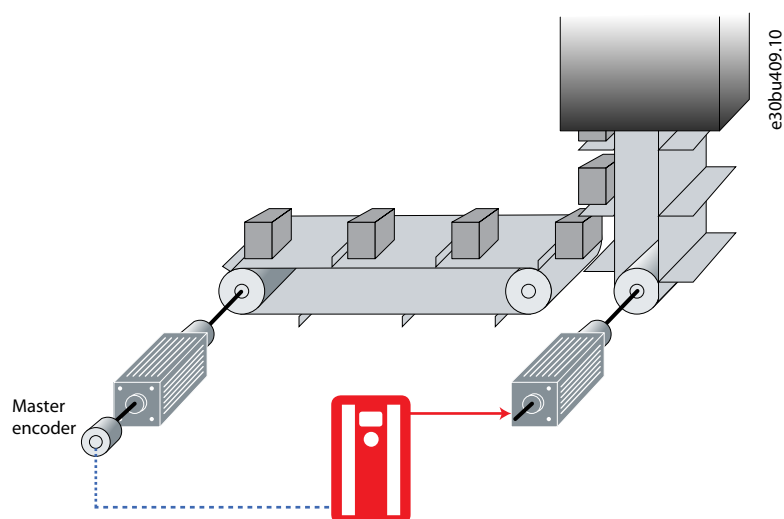


Illustration 46: Synchronizing with External Master and Homing

### 3.5.1 Control by Digital I/O

Following are the recommended parameter settings for the application when controlled by I/O.

**Table 13: Parameter Settings and Descriptions**

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[10] Synchronizing	Sets synchronizing control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-22 Master scale numerator	15	The gear ratio is set as a fraction to avoid rounding errors.
3-23 Master scale denominator	10	The factors must be set as integers, so 1.5 and 1 are both multiplied by 10.
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor while maintaining current position.
5-12 Terminal 27 Digital input	[110] Start Homing	Use input 27 as start homing to activate the selected home function <i>parameter 17-80 Homing Function</i> .
5-13 Terminal 29 Digital input	[113] Enable Reference	Input 29 activates synchronizing. The actual follower position is locked to actual master position.
5-14 Terminal 32 Digital input	[0] No operation	Used for 24 V encoder.
5-15 Terminal 33 Digital input	[0] No operation	Used for 24 V encoder.
5-40.0 Function relay	[226] On target	Use relay 1 to signal that synchronizing accuracy is within the window set in <i>parameter 3-08 Target Window</i> .
5-70 Term 32/33 Pulses Per Revolution		Configuration of encoder interface.
5-71 Term 32/33 Pulses Per Revolution		
5-72 Term 32/33 Encoder Type		
17-80 Homing function	[11] Reverse with sensor	Performs a search in reverse direction for homing on sensor.
17-83 Homing speed	100 RPM	Speed required for homing.

#### 3.5.1.1 Connections

The illustration depicts connection for synchronization with external master when controlled by digital I/O.

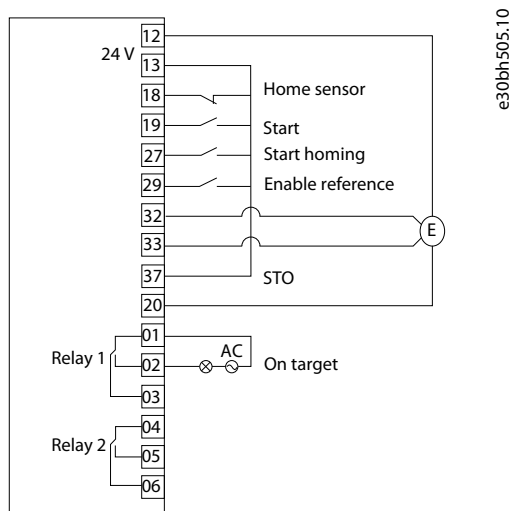


Illustration 47: Synchronization - control by digital I/O

### 3.5.2 Control by Fieldbus

Following are the recommended parameter settings for the application when offset adjustment is controlled via fieldbus.

Table 14: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[10] Synchronizing	Set synchronizing control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-22 Master scale numerator	15	The gear ratio is set as a fraction to avoid rounding errors. The factors must be set as integers, so 1.5 to 1 are both multiplied by 10.
3-23 Master scale denominator	10	
4-10 Motor speed direction	[2] Both directions	Enables motor rotation in both directions.
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as home sensor input. The option sets low signal with active sensor.
5-14 Terminal 32 Digital input	[0] No operation	Used for 24 V encoder.
5-15 Terminal 33 Digital input	[0] No operation	Used for 24 V encoder.
5-70 Term 32/33 Pulses Per Revolution		Configuration of encoder interface.
5-71 Term 32/33 Pulses Per Revolution	[8] Start	
5-72 Term 32/33 Encoder Type	[16] Preset ref bit 0	
8-01 Control Site	[2] Control Word only	Control via fieldbus control word.
9-15.2 PCD Write Configuration	[326] Master Offset	Sets the position offset between master and follower. 2 PCD's are needed for a 32 bit value.
9-15.3 PCD Write Configuration		

Parameter number and name	Setting for the application	Description of the setting
9-15.4 PCD Write Configuration	[328] Master Offset Speed Ref	Sets the speed with which the offset is executed/adjusted.
9-16.2 PCD Read Configuration	[1608] Position Error	PCD 2 and 3 are used to read position error as a 32-bit value.
9-16.3 PCD Read Configuration	[1608] Position Error	
17-80 Homing function	[11] Reverse with sensor	Performs a search for the homing sensor in reverse direction.
17-83 Homing speed	100 RPM	Sets the speed required for homing.

### 3.5.2.1 Connections

The illustration depicts the connection for synchronization with external master when controlled by fieldbus.

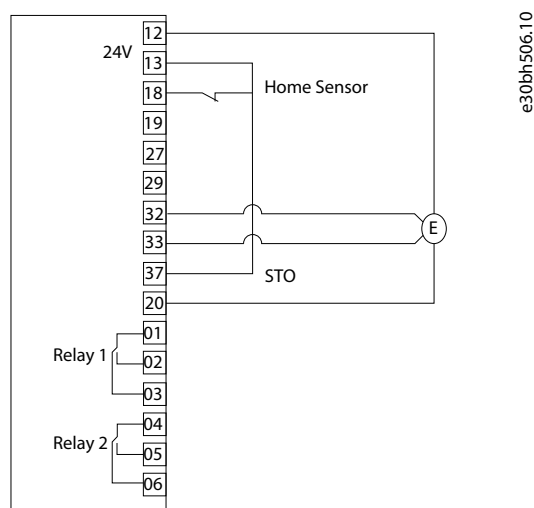


Illustration 48: Synchronization - controlled by fieldbus

### 3.5.2.2 Control Word Examples

Function	Binary	Hexadecimal	Description
Start Homing (bit 11)	0000 1100 0001 1000	0C18	Homing is also possible with active start signal (0C58).
Start (bit 6)	0010 0100 0101 1000	0458	Magnetizes the motor maintaining the current position.
Enable reference (bit 5)	0000 0100 0111 1000	0478	Activates synchronizing. The actual follower position is locked to actual master position.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start, speed mode, and touch signals (34D8).



### 3.5.2.3 Status Word Examples

Function	Binary	Hexadecimal	Description
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0110 0000 1000	060B	Drives has stopped with an alarm. Status can be read in parameters 16-9x.
Homing done (bit 4)	0000 1110 0001 0111	0E17	The selected homing function has been completed.
Target reached (bit 8)	0000 1111 0001 0111	0F17	Synchronizing, accuracy within <i>parameter 3-08 On Target Window</i> .

### 3.5.2.4 Fieldbus Data Layout

Following are the fieldbus data layout to read from or write to a drive, when synchronizing with external master.

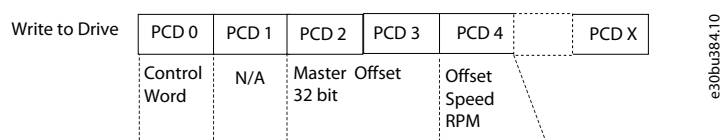


Illustration 49: Read from Drive

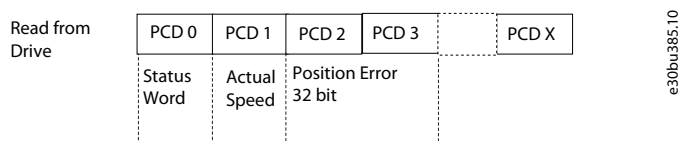


Illustration 50: Write to Drive

## 3.6 Synchronizing with Virtual Master

In this concept, 2 different applications are considered when control is via digital inputs and fieldbus. See [3.5.1 Control by Digital I/O](#) and [3.6.2 Control by Fieldbus](#)

### 3.6.1 Control by Digital I/O

This application illustration shows 2 conveyors synchronized in position to a common master signal. Each conveyor runs on a PM motor with sensorless control by VLT® AutomationDrive FC 302. Speed control of the virtual master by analog input 0–10 V corresponding to 0–1500 RPM on the followers. Homing on sensor of both drives is performed to align before start of synchronization.

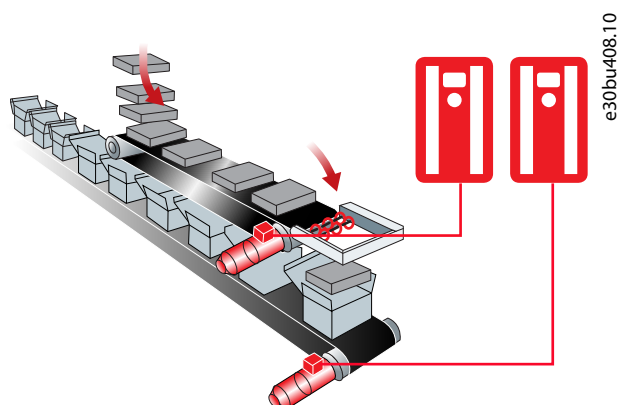


Illustration 51: Synchronizing with Virtual Master - Digital I/O Control

Table 15: Parameter Settings and Descriptions

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration Mode	[10] Synchronizing	Synchronizing control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-22 Master scale numerator	15	The gear ratio is set as a fraction to avoid rounding errors. The factors must be set as integers, so 1.5 to 1 are both multiplied by 10.
3-23 Master scale denominator	10	
5-10 Terminal 18 Digital input	[116] Home sensor inverse	Use input 18 as Home sensor input. The option sets low signal with active sensor.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option magnetizes motor and maintains current position.
5-15 Terminal 33 Digital input	[0] No operation	Used for 24 V encoder
5-40.0 Function relay	[223] On target	Use relay 1 to signal that synchronizing accuracy is within the window set by parameter 3-08 Target Window.
5-75 Term 27/29 Pulses Per Revolution	[1024]	Set the number of pulses per master revolution. The number should be the same for master (output) and follower (input).
17-80 Homing function	[10] Forward with sensor	Performs a search for the homing sensor in forward direction.
17-92 Position control selection	[2] Enable reference	Synchronization starts with the activation of start signal.

Configuration of virtual master function, only in the drive which hosts the virtual master (follower 1):

Table 16: Parameter Settings and Description

Parameter number and name	Setting for the application	Description of the setting
3-15 Reference Resource 1	[1] Analog input 53	Virtual master reference.

Parameter number and name	Setting for the application	Description of the setting
3-16 Reference Resource 2	[6] Virtual master	Select virtual master as synchronization master signal, no external connection needed.
3-27 Virtual Master Max Ref	50 Hz	Enter the maximum reference for the virtual master. The actual reference is set relative to this value using the source selected in <i>parameter 3-15 Reference Resource 1</i> or fieldbus reference 1.
5-01 Terminal 27 mode	[1] Output	Terminal 27 is used as output.
5-02 Terminal 29 mode	[1] Output	Terminal 29 is used as output.
5-14 Terminal 32 Digital input	[109] Enable Virtual Master	Digital input for start/stop of virtual master.
5-30 Terminal 27 Digital output	[54] 24 V Encoder Sim	Terminal 27 is used for encoder simulation.
5-31 Terminal 29 Digital output	[54] 24 V Encoder Sim	Terminal 29 is used for encoder simulation.
5-75 Term 27/29 Pulses Per Revolution	1024	Set the number of pulses per revolution for the encoder simulation.
5-78 Term 27/29 Encoder Sim	[3] Vir. Master Position	Select virtual master as source for the encoder simulation.

Configuration of synchronization master signal in follower without virtual master (follower 2):

Table 17: Parameter Settings and Description

Parameter number and name	Setting for the application	Description of the setting
3-16 Reference Resource 2	[13] 24 V Encoder 27/29	Select 24 V encoder signal from virtual master as synchronization master signal.
5-12 Terminal 27 Digital Input	[0] No operation	Digital inputs 27 and 29 are used as 24 V encoder input.
5-13 Terminal 29 Digital Input	[0] No operation	

### 3.6.1.1 Connections

The illustration shows connection for synchronization with virtual master when controlled by digital I/O.

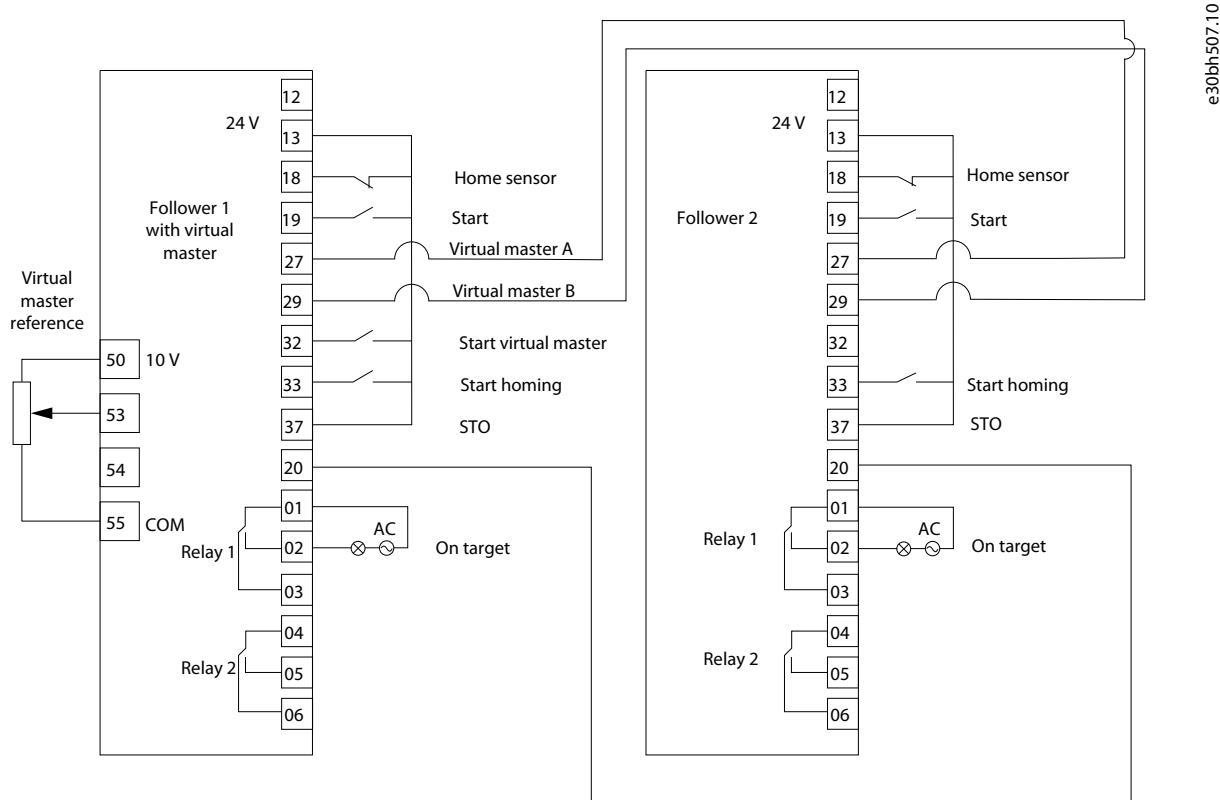


Illustration 52: Virtual Master Synchronization - Digital I/O

### 3.6.2 Control by Fieldbus

Consider a platform lift application with the following:

- 4 screw actuators each with a PM motor and a mechanical brake. The 4 motors are synchronized in position to a virtual master hosted by 1 of the drives.
- Position control of the virtual master is set by fieldbus reference.
- Sensorless synchronizing control of the 4 PM motors.
- Homing on sensor of all 4 drives to align before synchronization start.

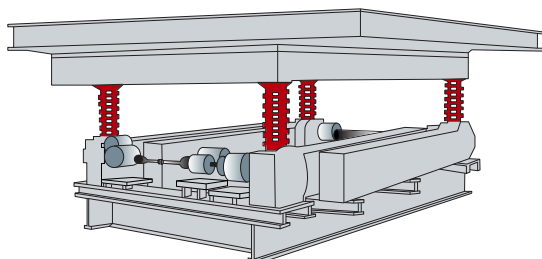


Illustration 53: Synchronizing with Virtual Master - Fieldbus Control

**Configuration of Synchronizing Control in All 4 Drives:**
**Table 18: Parameter Settings and Descriptions**

Parameter number and name	Setting for the application	Description of the setting
1-00 Configuration mode	[10] Synchronizing	Synchronizing control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
1-67 Load Type	[1] Active Load	Select <i>Active Load</i> when torque must be applied to hold load in position.
1-72 Start Function	[6] Hoist Mech Brake Rel	For jerk-free transition between mechanical brake and holding torque. Tuning via <i>parameters 2-24 to 2-29</i> .
3-22 Master scale numerator	1	The gear ratio is set as a fraction to avoid rounding errors. All 4 drive trains are identical, so the ratio is 1:1.
3-23 Master scale denominator	1	
4-10 Motor speed direction	[2] Both directions	Enables movement in both directions.
5-10 Terminal 18 Digital input	[116] Home Sensor Inverse	Use input 18 as Home sensor input. The option sets low signal with active sensor.
5-14 Terminal 32 Digital Input	[0] No operation	Used for 24 V Encoder
5-15 Terminal 33 Digital Input	[0] No operation	Used for 24 V Encoder
5-40.0 Function Relay	[32] Mech brake control	Relay 1 is used to control the mechanical brake.
8-01 Control Site	[2] Control word only	Control signals only from fieldbus.
9-16.2 PCD Read Configuration	[1608] Position Error	Use PCD 2 and 3 to read position error as a 32-bit value.
9-16.2 PCD Read Configuration	[1608] Position Error	
17-80 Home Function	[10] Forward with Sensor	Use homing on sensor with search for sensor in forward direction.

**Configuration of virtual master function, only in the drive which hosts the virtual master (Follower 1):**
**Table 19: Parameter Settings and Descriptions**

Parameter number and name	Setting for the application	Description of the setting
3-16 Reference resource 2	[6] Virtual master	Select virtual master as synchronization master signal. An external connection is not needed.
3-27 Virtual Master Max Ref	50 Hz	Enter the maximum reference for the virtual master. The actual reference is set relative to this value using the source selected in <i>parameter 3-15 Reference Resource 1</i> or fieldbus reference 1.
5-01 Terminal 27 mode	[1] Output	Terminal 27 used as output.
5-02 Terminal 29 mode	[1] Output	Terminal 29 used as output.
5-30 Terminal 27 Digital output	[54] 24 V Encoder Sim	Terminal 27 used for encoder simulation.
5-31 Terminal 29 Digital output	[54] 24 V Encoder Sim	Terminal 29 used for encoder simulation.
5-75 Term 27/29 Pulses per revolution	1024	Set the number of pulses per revolution for the encoder simulation. Should be the same as <i>parameter 5-70 Term 32/33 Pulses Per Revolution</i> in followers 2-4.

Parameter number and name	Setting for the application	Description of the setting
5-78 Term 27/29 Encoder Sim	[3] Vir. Master Position	Select virtual master as source for the encoder simulation.
8-14.0 Configurable Control Word	[18] Enable Vir. Master	Bit 0 activates the virtual master. Ramps for starting and stopping the virtual master is set by <i>parameter group 3-6* Ramp 3</i> .
8-14.14 Configurable Control Word CTW	[28] Position Vir. Master	Select position-controlled virtual master, as target position is set by fieldbus.
9-15.2 PCD Write Configuration REF	[1683] Fieldbus Pos.REF	PCD 2 and 3 as 32-bit target position for the virtual master. Fieldbus REF 1 is speed reference for the virtual master.

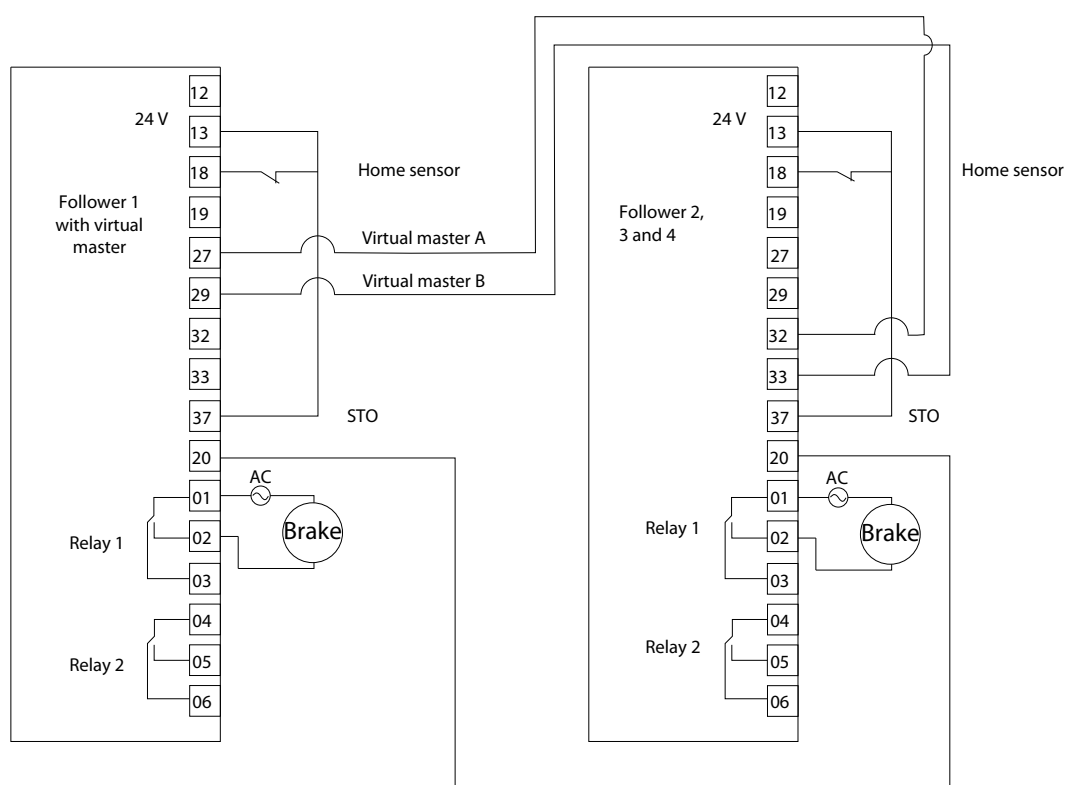
### Configuration of synchronization master signal in followers without virtual master (follower 2-4)

Table 20: Parameter Settings and Descriptions

Parameter number and Name	Setting for the application	Description of the setting
3-16 Reference resource 2	[3] 24V Encoder 32/33	Select 24 V encoder signal from virtual master as synchronization master signal.
5-12 Terminal 32 Digital Input	[0] No operation	Digital inputs 32 and 33 are used as 24 V encoder input.
5-13 Terminal 33 mode	[0] No operation	
5-70 Term 32/33 Pulses per Revolution	1024	Set the number of pulses per revolution for the master signal. Should be the same as set in <i>parameter 5-75</i> for follower 1.

#### 3.6.2.1 Connections

The illustration shows synchronization with virtual master when controlled by fieldbus.



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Illustration 54: Synchronization with Virtual master - fieldbus

### 3.6.2.2 Control Word Examples

Function	Binary	Hexadecimal	Comment
Start homing (bit 11)	0000 1100 0001 1000	0C18	Homing is also possible with active start signal (0C58)
Start (bit 6)	0000 0100 0101 1000	0458	Magnetizes motor which maintains current position.
Enable reference (bit 5)	0000 0100 0111 1000	0478	Reset is also possible with active start and enable reference such as 04F8.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start and enable reference such as 04F8.
Enable virtual master (bit 0) and selection of virtual master positioning (bit 14). Only for drive which hosts the virtual master.	0100 0100 0111 1001	4479	Activates the virtual master positioning while the follower is synchronizing.

### 3.6.2.3 Status Word Examples

Function	Binary	Hexadecimal	
Coasting (bit 2)	0000 0110 0000 0011	0603	
Tripped (bit 3)	0000 0110 0000 1011	060B	
Homing done (bit 4)	0000 1110 0001 0111	0E17	
Target reached (bit 8)	0000 1111 0001 0111	0F07	Synchronizing, accuracy within <i>parameter 3-08 On Target Window</i> .
Target not reached (bit 8)	0000 1110 0001 0111	0E07	Synchronizing, accuracy not within <i>parameter 3-08 On Target Window</i> .

### 3.6.2.4 Fieldbus Data Layout

Following is the fieldbus data layout for reading from drive and writing to drive, when synchronizing with virtual master.

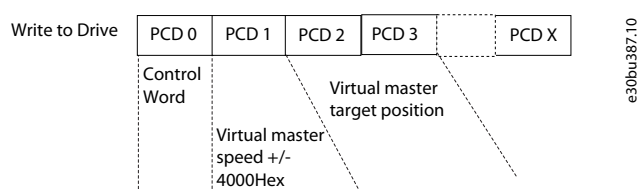


Illustration 55: Write to drive

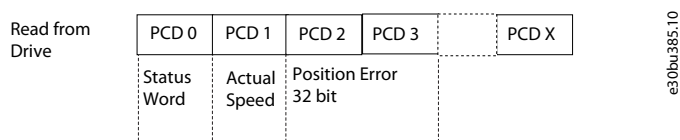


Illustration 56: Read from drive

## 3.7 Synchronizing with Marker Correction

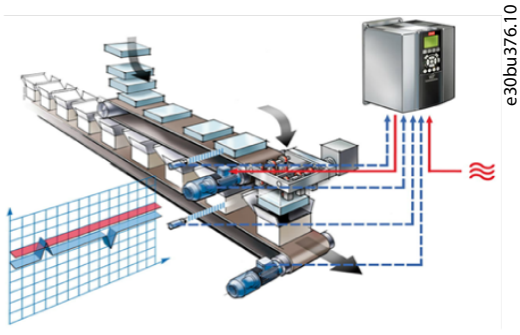
An object on the upper conveyor has to be aligned with the box on the lower conveyor. As the objects and boxes are not fixed to the conveyors, synchronizing the position of the conveyors is not sufficient. Position of the object and the box on the conveyors must be aligned.

In the illustration below, the lower conveyor is the master and the upper conveyor is controlled by the follower drive. Sensors detect the position of the object and the box by providing marker signals. Marker signals automatically adjust the offset of the follower drive. The follower drive controls the upper conveyor, synchronizes, and performs marker correction to align product with the box on the lower conveyor. This is performed using the encoder signal from the lower (master) conveyor and the 2 marker signals.

The blue lines indicate communication from the encoders and sensors to the drive. The red lines indicate communication from the drive to the encoder and the connection to power supply.

Illustration 57: Synchronizing with Marker Correction





### 3.7.1 Control by Digital I/O

Following are the recommended parameter settings when controlled by digital I/O.

Parameter number and name	Setting	Description
1-00 Configuration Mode	[10] Synchronizing	Synchronizing control.
1-01 Motor Control Principle	[2] Flux Sensorless	Motor and position control without feedback.
3-16 Reference Resource 2	[3] 24 V Encoder 32/33	Select 24 V encoder on input 32/33 as master signal.
3-22 Master scale numerator	1	The gear ratio is set as a fraction to avoid rounding errors. In this example the 2 conveyors are identical, hence the gear ratio is 1-1.
3-23 Master scale denominator	1	The gear ratio is set as a fraction to avoid rounding errors. In this example the 2 conveyors are identical, hence the gear ratio is 1-1.
3-33 Sync Mode & Start Behavior	[10] Marker shortest	<p>Activates marker correction while synchronizing. Start-up of the follower marker is aligned with the closest master marker when the marker distance is set in <i>parameter 3-34 Marker Distance</i>.</p> <p>If the marker distance is not set, the 1<sup>st</sup> follower marker aligns with the 1<sup>st</sup> master marker.</p> <p>The start behavior can be configured to always catch up or slow down for the 1<sup>st</sup> marker correction.</p>
3-34 Marker Distance		<p>Monitoring or filtering of the marker signals can be activated by setting <i>parameter 3-34 Marker Distance</i> and <i>parameter 3-35 Marker Window</i>.</p> <p>After detecting the 1<sup>st</sup> marker pulse, the consequent marker pulse is only accepted if the position is within the marker distance +/- the marker window and only the 1<sup>st</sup> pulse within the window.</p> <p>Hence the maker pulses outside the window or multiple pulses within the window are ignored.</p>
3-35 Marker Window		<p>Monitoring or filtering of the marker signals can be activated by setting <i>parameter 3-34 Marker Distance</i> and <i>parameter 3-35 Marker Window</i>.</p> <p>After detecting the 1<sup>st</sup> marker pulse, the consequent marker pulse is only accepted if the position is within the marker distance +/- the marker window and only the 1<sup>st</sup> pulse within the window.</p> <p>Hence, the marker pulses outside the window or multiple pulses within the window are ignored.</p>
4-10 Motor speed direction	[2] Both directions	Enables movement in both directions.
5-10 Terminal 18 Digital input	[113] Enable reference	Input 29 activates synchronizing. The actual follower position is locked to actual master position.
5-11 Terminal 19 Digital input	[8] Start	Use input 19 as start. The option setting magnetizes motor and maintains current position.
5-12 Terminal 27 Digital input	[123] Master Marker	Connect master marker sensor to input 27.
5-13 Terminal 29 Digital input	[125] Follower Marker	Connect follower marker sensor to input 29.

Parameter number and name	Setting	Description
5-14 Terminal 32 Digital input	[0] No operation	Used for 24 V master encoder.
5-15 Terminal 33 Digital input	[0] No operation	Used for 24 V master encoder.
5-40.0 Function relay	[226] On target	Use relay 1 to signal that synchronizing accuracy is within the window set by parameter 3-08 Target Window.
5-70 Term 32/33 Pulses Per Revolution		Configuration of encoder interface according to specifications of the encoder.
5-71 Term 32/33 Encoder Direction		Configuration of encoder interface according to specifications of the encoder.
5-72 Term 32/33 Encoder Type		Configuration of encoder interface according to specifications of the encoder.

### 3.7.1.1 Connections

Following is the connection illustration for synchronizing marker corrections using digital I/O control.

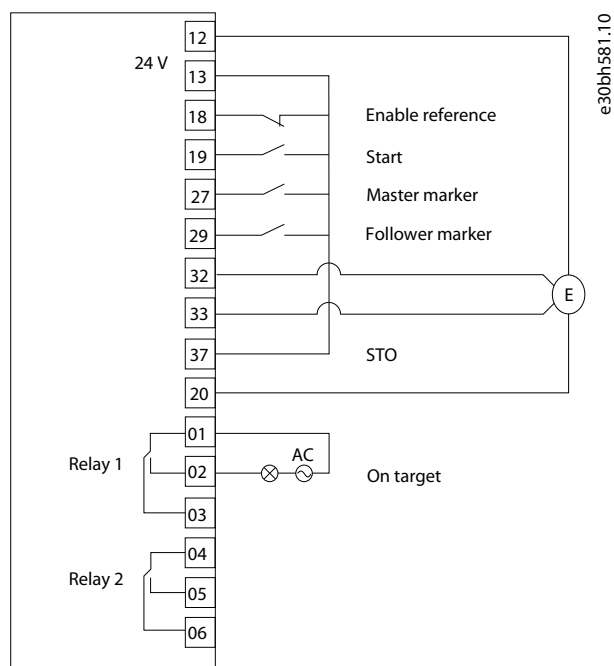


Illustration 58: Marker Synchronization - Digital I/O

### 3.7.2 Control by Fieldbus

Following are the recommended parameter settings when controlled by PROFIBUS.

Parameter number and name	Setting	Description
1-00 Configuration Mode	[10] Synchronizing	Synchronizing control.
1-01 Motor Control Principle	[2] Flux sensorless	Motor and position control without feedback.
3-16 Reference Resource 2	[3] 24V Encoder 32/33	Select 24 V encoder on input 32/33 as master signal.
3-22 Master scale numerator	1	The gear ratio is set as a fraction to avoid rounding errors. In this example the 2 conveyors are identical, hence the gear ratio is 1:1.
3-23 Master scale denominator	1	The gear ratio is set as a fraction to avoid rounding errors. In this example the 2 conveyors are identical, hence the gear ratio is 1:1.
3-33 Sync Mode & Start Behavior	[10] Marker shortest	<p>Activates marker correction while synchronizing. Start-up of the follower marker is aligned with the closest master marker when the marker distance is set in <i>parameter 3-34 Marker Distance</i>.</p> <p>If the marker distance is not set, the 1<sup>st</sup> follower marker aligns with the first master marker.</p> <p>The start behavior can be configured to either always catch up or slow down for the 1<sup>st</sup> marker correction.</p>
3-34 Marker Distance		<p>Monitoring or filtering of the marker signals can be activated by setting <i>parameter 3-34 Marker Distance</i> and <i>parameter 3-35 Marker Window</i>.</p> <p>After detecting the 1<sup>st</sup> marker pulse, the consequent marker pulse is only accepted if the position is within the marker distance +/- the marker window. Only the 1<sup>st</sup> pulse within the window is accepted. Hence, the marker pulses outside the window or multiple pulses within the window are ignored.</p>
3-35 Marker Window		<p>Monitoring or filtering of the marker signals can be activated by setting <i>parameter 3-34 Marker Distance</i> and <i>parameter 3-35 Marker Window</i>.</p> <p>After detecting the 1<sup>st</sup> marker pulse, the consequent marker pulse is only accepted if the position is within the marker distance +/- the marker window. Only the 1<sup>st</sup> pulse within the window is accepted.</p> <p>Hence the marker pulses outside the window or multiple pulses within the window are ignored.</p>
4-10 Motor speed direction	[2] Both directions	Enables movement in both directions.
5-12 Terminal 27 Digital input	[123] Master Marker	Connect master marker sensor to input 27.
5-13 Terminal 19 Digital input	[125] Follower Marker	Connect follower marker sensor to input 29.
5-14 Terminal 32 Digital input	[0] No operation	Used for 24 V master encoder.
5-15 Terminal 33 Digital input	[0] No operation	Used for 24 V master encoder.
5-70 Term 32/33 Pulses Per Revolution		Configuration of encoder interface according to the specifications of the encoder.
5-71 Term 32/33 Encoder Direction		

Parameter number and name	Setting	Description
5-72 Term 32/33 Encoder Type		
8-01 Control Site	[2] Control Word only	Control via fieldbus only.
9-16.2 PCD Read Configuration	[1608] Position Error	Use PCD 2 and 3 to read position error as a 32-bit value.
9-16.3 PCD Read Configuration	[1608] Position Error	Use PCD 2 and 3 to read position error as a 32-bit value.
9-16.4 PCD Read Configuration	[1821] Master Position	Use PCD 4 and 5 to read master position as a 32-bit value.
9-16.5 PCD Read Configuration	[1821] Master Position	Use PCD 4 and 5 to read master position as a 32-bit value.

### 3.7.2.1 Connections

Following is the connection diagram for marker synchronization when controlled by fieldbus (PROFIBUS).

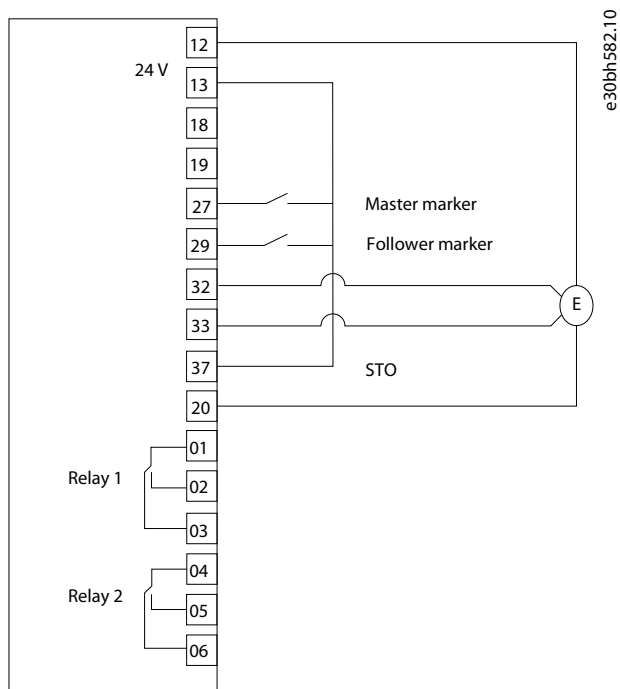


Illustration 59: Marker Synchronization - PROFIBUS

### 3.7.2.2 Control Word Examples

Table 21: Control Word examples

Function	Binary	Hexadecimal	Comment
Start (bit 6)	0000 0100 0101 1000	0458	Magnetizes the motor maintaining the current position.
Enable reference (bit 5)	0000 0100 0111 1000	0478	Activates synchronizing. Actual follower position is locked to actual master position.
Reset (bit 7)	0000 0100 1001 1000	0498	Reset is also possible with active start, speed mode, and touch signals, such as 34D8.

### 3.7.2.3 Status Word Examples

Table 22: Status word examples

Function	Binary	Hexadecimal	Comment
Coasting (bit 2)	0000 0110 0000 0011	0603	Drive is coasting, motor is not controlled.
Tripped (bit 3)	0000 0110 0000 1011	060B	Drives has stopped with an Alarm, alarm type and status can be read in parameters 16-9x.
Target reached (bit 8)	0000 1111 0001 0111	0F17	Synchronizing, accuracy within <i>parameter 3-08 On Target Window..</i>

### 3.7.2.4 Fieldbus Data Layout

The illustrations show fieldbus data layout for reading from the drive or writing to the drive, when synchronizing with marker correction.

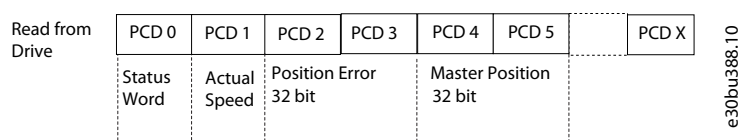


Illustration 60: Read from Drive

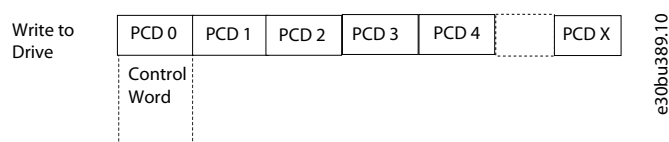


Illustration 61: Write to Drive

## 4 Scaling and Synchronization Gear Ratio

### 4.1 Scaling of Position Units

IMC supports scaling of position units. 3 examples of linear belt drive are considered to provide recommended parameter settings for position values. Set position values in *parameter 17-72 Position Unit Numerator* and *parameter 17-73 Position Unit Denominator*. To obtain right scaling, set values in *parameter 7-94 Position PI Feedback Scale Numerator* and *parameter 7-95 Position PI Feedback Scale Denominator*.

#### 4.1.1 Example 1

Linear belt drive with pulley wheel direct on motor. Pulley wheel has 32 teeth and timing belt is 10 mm.

Linear movement per motor revolution is  $32 \times 10 = 320$  mm.

For position values in mm, set *parameter 17-72 Position Unit Numerator* = 320 and *parameter 17-73 Position Unit Denominator* = 1.

#### 4.1.2 Example 2

Consider a linear belt drive using a VLT® OneGearDrive (OGD) with gear ratio of 14.13. 14.13 is a rounded value.

The actual gear ratio of this 2 stage gear is stage one 43/7 and stage two 46/20. Without making rounding errors, the resulting ratio is  $43 \cdot 23 : 7 \cdot 10 = 989 : 70$

For position values in mm, set *parameter 17-72 Position Unit Numerator* =  $320 \cdot 70 = 22400$  and *parameter 17-73 Position Unit Denominator* = 989.

Where

- 320 is the motor revolution
- 70 is the denominator of the gear ratio
- 989 is the numerator of the gear ratio

#### 4.1.3 Example 3

Consider a linear belt drive using a VLT® OneGearDrive (OGD) in a closed loop control and with an encoder mounted on the pulley wheel shaft. The gear ratio is 14.13 which is a rounded value.

To obtain the right scaling between motor and encoder, set *parameter 7-94 Position PI Feedback Scale Numerator* to 70 and *parameter 7-95 Position PI Feedback Scale Denominator* to 989

Where

- 70 is the denominator of the resulting ratio.
- 989 is the numerator of the resulting ratio.

See Example 2 for calculation of resulting ratio.

### 4.2 Gear Ratio for Synchronization

The gear ratio between master and follower is set by determining the number of revolutions the follower shall move per master revolution.

When an encoder is master, 1 master revolution is defined as 1 encoder revolution. For a virtual master, one master revolution is defined by the encoder output resolution.

The following examples shows how to determine accurate master scaling. Using the following example, 3 scenarios are described.

**Example:** Consider 2 identical conveyor belts driven by 2 different VLT® One Gear Drive. The master OGD has a gear ratio of 31.12 and the follower OGD has a gear ratio (i) of 5.92. The gear ratio is the same independent of whether the follower control configuration is with or without encoder feedback.

### 4.2.1 Scenario 1

The master encoder is placed on the conveyor shaft, which indicates that the master encoder is placed after the gearbox. Hence, the master OGD gear ratio of the master OGD is not considered.

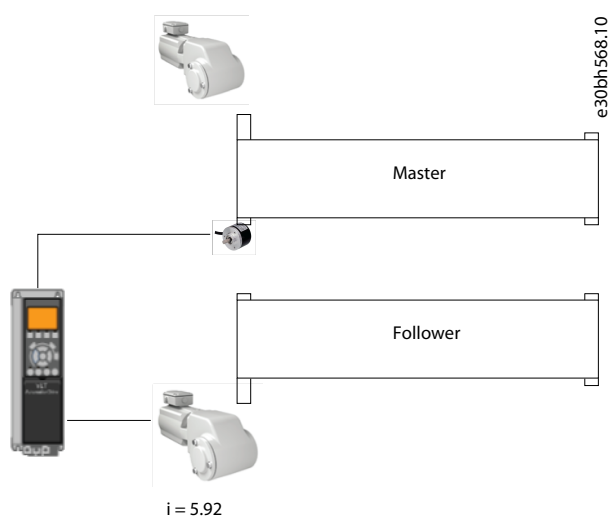


Illustration 62: Master encoder after the gearbox

Stage 1: 43/7

Stage 2: 27/28

Resulting Ratio:  $43 \times 27 : 7 \times 28 = 1161:196$

The resulting ratio indicates that 196 master encoder revolutions correspond to 1161 follower motor revolutions.

Set the following parameters for the follower conveyor belt.

- parameter 3-22 Master Scale Numerator to 196
- parameter 3-23 Master Scale Denominator to 1161

This setting allows the follower conveyor belt to move the same distance as the master conveyor belt.

### 4.2.2 Scenario 2

Master encoder is placed on the master motor which indicates that the master encoder is placed before the gearbox. Therefore, the master signal must be scaled with both the master OGD gear ratio and the follower OGD gear ratio.



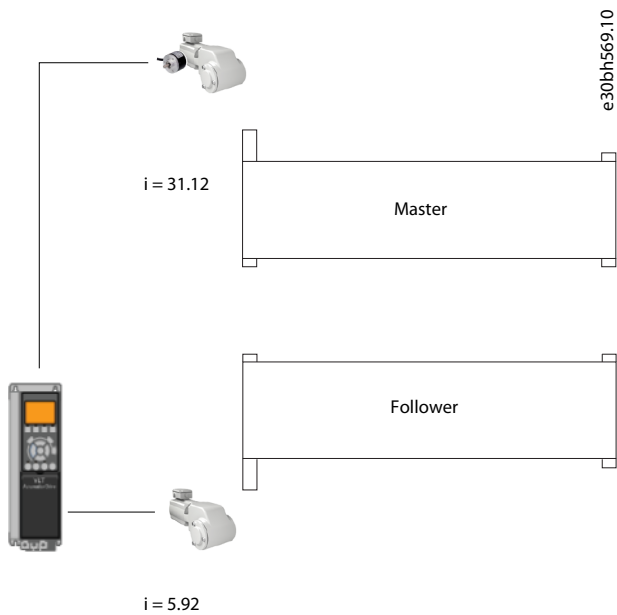


Illustration 63: Master Encoder before the Gear Box

Stage 1: 43/7

Stage 2: 76/15

Resulting ratio:  $43 \times 76 : 7 \times 15 = 3268 : 105$

When multiplied by existing ratio:  $196 \times 3268 : 1161 \times 105 = 640528 : 121905$

Reduced ratio: 2128 : 405

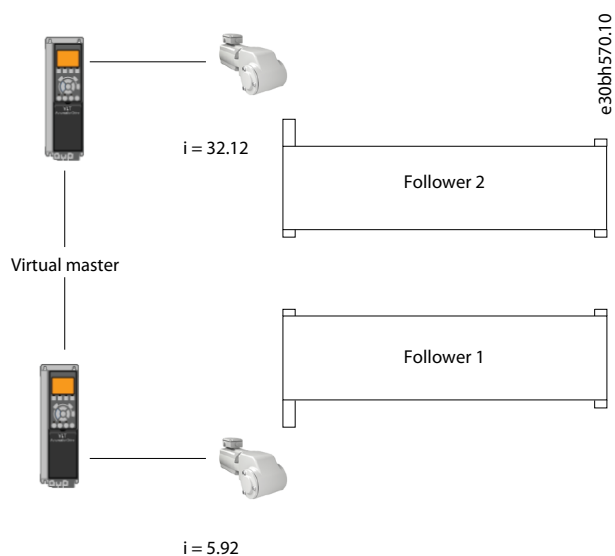
Set the parameter as follows:

- parameter 3-22 Master Scale Numerator to 2128.
- parameter 3-23 Master Scale Denominator to 405

In this scenario, for every 2128 revolutions of the master motor/encoder the follower motor must make 405 revolutions for the 2 conveyor belts to move the exact same distance.

### 4.2.3 Scenario 3

In this scenario, both drives are followers synchronizing to a virtual master signal, as shown.



**Illustration 64: Drives Synchronizing to Virtual Master Signal**

- Follower 1 OGD has  $i=5.92$
- Follower 2 OGD has  $i=31.12$

Ratio for followers is calculated using the OGD.

Ratio for follower 1 is 196:1161. See Scenario 1.

Ratio for follower 2 is 3268:105. See Scenario 2.

Set parameters as follows:

- *parameter 3-22 Master Scale Numerator* to 105
- *parameter 3-23 Master Scale Denominator* to 3268

The parameter setting indicates that for each master revolution, the follower 1 must make 5.92 motor revolutions. Follower 2 must make 31.12 motor revolutions for the 2 conveyor belts to move the same distance.

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