YASKAWA

YASKAWA AC Drive - A1000

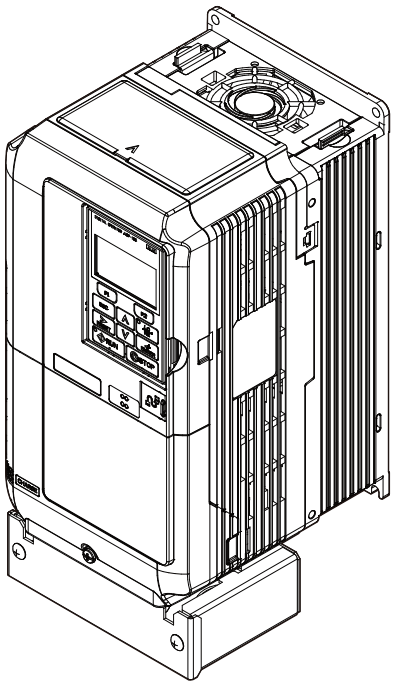
Electronic Line Shaft with Alignment

Custom Software Supplement

Software Number: VSA91003□

Drive Models: AU□A□□□□□□□-064
AU□A□□□□□□□-065

To properly use the product, read this manual thoroughly and retain for easy reference, inspection, and maintenance. Ensure the end user receives this manual.



MANUAL NO. TM.A1000SW.064

CONFIDENTIAL

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Refer to the A1000 Technical Manual for content not described in this document.

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1 Preface and Safety

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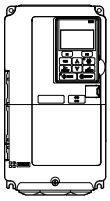
◆ Applicable Documentation

The following manuals are available for the A1000 Drive:

Custom Software Supplement

	Yaskawa AC Drive - Electric Line Shaft with Simple Automatic Alignment A1000 Custom Software Supplement **Manual No: TM.A1000SW.064**
	Read this manual first. This supplement is an addendum to the A1000 Quick Start Guide and Technical Manual. It lists the effects of this custom software on the parameters in the drive and function descriptions in the manual. To obtain the supplement access this site: U.S: http://www.yaskawa.com

Yaskawa Drive

	**Yaskawa AC Drive - A1000 Quick Start Guide**	To obtain instruction manuals for Yaskawa products access these sites: U.S.: http://www.yaskawa.com Europe: http://www.yaskawa.eu.com Japan: http://www.e-mechatronics.com Other areas: contact a Yaskawa representative. For questions, contact the local Yaskawa sales office or the nearest Yaskawa representative.
	Yaskawa AC Drive - A1000 Technical Manual	

◆ Supplemental Safety Information

Read and understand this manual and the A1000 Quick Start Guide before installing, operating, or servicing this option unit. Install the drive according to the A1000 Quick Start Guide and local codes. Observe all cautions and warnings in this document and the standard drive technical manuals.

Refer to the A1000 Quick Start Guide and Technical Manual for safety information and to install and start-up the drive.

This document is a supplement to the standard drive technical manual. It describes the effects on the drive parameters and functions with the software installed.

- Custom software is provided to add functionality to a standard drive to enhance or enable use in a specific application.
- The software is loaded to the flash ROM area of the control board, and replaces the standard drive software.

◆ Obtaining Support

When seeking support for a drive with custom software, it is imperative to provide the unique part number shown on the drive nameplate. The software is flashed to the control board memory and the operation of parameters, functions, and monitors are different than the standard drive software, as described herein.

Refer to Yaskawa office locations listed on the back cover of this manual.

2 Electronic Line Shaft

◆ Overview

The Electronic Line Shaft (ELS) function allows a drive to precisely follow the speed, direction, and phase of a master encoder (PG) signal. The follower can match its position (phase angle) to the master within several quadrature encoder counts.

The ELS function is used in applications where the machinery being driven requires two mechanically isolated and motor-driven moving parts to maintain a constant position relationship. The gear ratio between the master and the follower is infinitely adjustable.

In addition, a gear ratio adjustment, or “draw”, can be added to the speed reference via parameter setting, analog input, multi-function input MOP, or serial communication. It is also possible to run the drive in a pure speed follower mode for applications that do not require matched position.

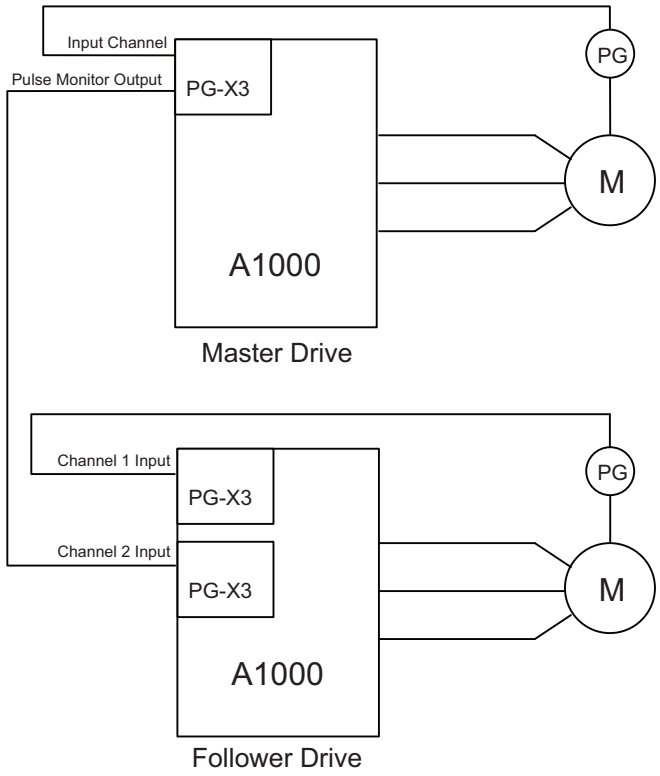


Figure 1 Typical Configuration Connection

◆ Basic Concepts and Principles

The master encoder signal is fed into a PG option card installed in the CN5-B port of the follower (PG Channel 2). When using V/f w/PG, CLV, or CLV/PM control modes, the encoder signal of the follower is fed into a PG option card installed in the CN5-C port of the follower (PG Channel 1) and the master encoder speed is multiplied by the programmed gear ratio to determine the frequency reference of the follower.

Setting parameter P1-01 to 4 or 5 configures the drive for ELS and ELS Signed Run modes. These configurations determine the error between the master and follower position and this error is fed into a PI controller, which is then added to the previously calculated frequency reference. The position regulator is disabled when the drive is configured only as a speed follower (non-ELS modes).

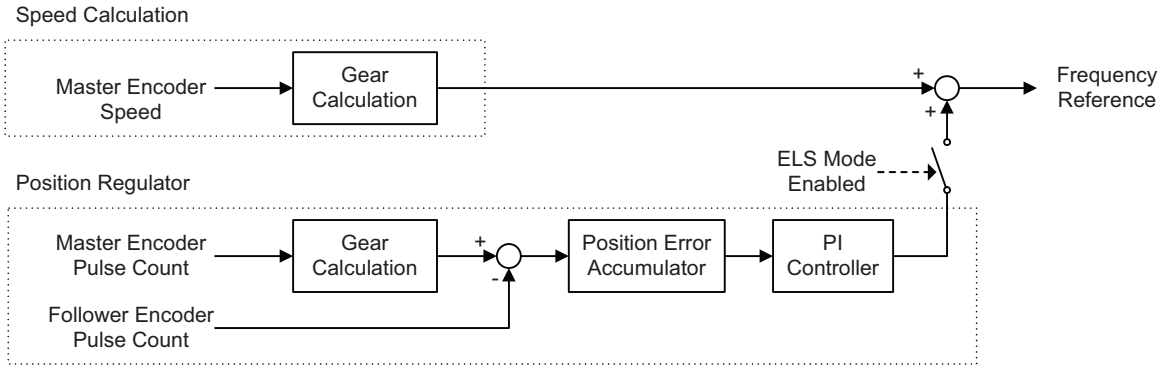


Figure 2 Simplified Block Diagram of ELS Function

The Signed Run mode ELS functions identically to the standard ELS mode with the following exceptions:

- When a reverse Run command is given, the follower will match the velocity and phase of the master, but in the opposite direction (i.e., if the master runs in the forward direction, the follower will run in reverse direction and if the master runs in the reverse direction, the follower will run in the forward direction).
- When a forward Run command is present, the follower will run in the same direction as the master.

◆ Changes from the Standard Product

- The Motor 2 Selection multi-function input setting is deleted (only Motor 1 can be used).
- The follower drive uses acceleration and deceleration times of zero during Electronic Line Shaft operation (P1-01 = 4 or 5).
- PG 2 related parameters F1-31 and F1-32 are always available and no longer require selecting Motor 2 via digital input.

◆ Limitations

- For ELS and ELS Signed Run modes (P1-01 = 4 or 5), Yaskawa recommends using Closed Loop Vector (A1-02 = 3) control mode.
- For Speed Follower Both Directions, ELS, and ELS Signed Run modes (P1-01 = 1, 4, or 5), install master and follower encoder feedback cards and set to quadrature encoder input (F1-21 and F1-37 = 1).
- For Speed Follower Both Directions mode (P1-01 = 1), set the master encoder input to quadrature encoder input (F1-37 = 1).
- For ELS and ELS Signed Run modes (P1-01 = 4 or 5), express the gear ratio exactly, including remainder, to prevent phase drift.
- Use the proper option card port for each encoder (PG) input. (CN5-B: Master Encoder, CN5-C: Follower Encoder).
- DriveWorksEZ is not currently supported with software version VSA910030.
- The LED keypad is not fully supported; some alarms and faults may not display properly on the LED keypad.

◆ Related Parameters and Functions

Table 1 lists terms and symbols used in this section to indicate which parameters are available in which control modes.

Table 1 Symbols and Icons Used in Parameter Descriptions

Symbol	Description
All Modes	Parameter is available in all control modes.
V/f	Parameter is available when operating the drive with V/f Control.
V/f w PG	Parameter is available when operating the drive with V/f with PG Control.
OLV	Parameter is available when operating the drive with Open Loop Vector.
CLV	Parameter is available when operating the drive with Closed Loop Vector.
OLV/PM	Parameter is available when operating the drive with Open Loop Vector for PM motors.
AOLV/PM	Parameter is available when operating the drive with Advanced Open Loop Vector for PM motors.
CLV/PM	Parameter is available when operating the drive with Closed Loop Vector for PM motors.
□□□□□	Parameter is NOT available when operating the drive in the control mode.
RUN	Parameter can be changed during run.
Motor 2	Refers to a second motor when the drive is operating two motors. Switch between these motors using the multi-function input terminals.

The parameters in the tables below are used to set up the drive for operation with the software.

Table 2 Modified Parameters

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
F1-01 (380)	PG1 Pulses per Revolution (PG Pulses/Rev)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the number of pulses for a PG option card connected to port CN5-C.	Default: 1024 ppr Min: 1 Max.: 60000
F1-02 (381)	Operation Selection at PG Open Circuit (PGo) (PG Fdbk Loss Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the operation when a PGo is detected on a PG option card connected to port CN5-C. 0: Ramp to Stop 1: Coast to Stop 2: Fast Stop 3: Alarm Only 4: No Alarm Display	Default: 1 Range: 0 to 4
F1-05 (384)	PG 1 Rotation Selection (PG1 Rotation Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the direction of forward travel for the PG card installed in CN5-C. 0: Pulse A Leads 1: Pulse B Leads	Default: 0 Range: 0, 1
F1-14 (38D)	PG Open-Circuit Detection Time (PGO Detect Time)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the amount of time required to trigger a PG Open fault (PGo).	Default: 2.0 s Min: 0.0 Max.: 10.0
F1-21 (3BC)	PG 1 Signal Selection (PG1 Signal Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects single-channel/quadrature detection mode for the PG option card 1. 0: A Pulse Detection 1: AB Pulse Detection	Default: 1 Range: 0, 1

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
F1-31 (3B0)	PG 2 Pulses per Revolution (PG Pulses/Rev 2)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the number of pulses for a PG option card connected to port CN5-B.	Default: 1024 ppr Min: 1 Max.: 60000
F1-32 (3B1)	PG 2 Rotation Selection (PG Rotation Sel2)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the direction of forward travel for a PG option card installed in port CN5-B. 0: Pulse A Leads 1: Pulse B Leads	Default: 0 Range: 0, 1
F1-36 (3B5)	PG Option Card Disconnect Detection 2 (Hardware PGO Ch2)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Determines whether the drive detects a fault when a PGo is detected on a PG option card installed in port CN5-B. 0: Disabled 1: Enabled	Default: 1 Range: 0, 1
F1-37 (3BD)	PG 2 Signal Selection (PG2 Signal Sel)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects single-channel/quadrature detection mode for the PG option card 2 installed in port CN5-B. 0: A Pulse Detection 1: AB Pulse Detection	Default: 1 Range: 0, 1

Table 3 Additional Parameters

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P1-01 (600)	Follower Mode Selection (Follower Mode)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects the follower mode. 0: Disabled. Follower mode is disabled and the follower drive runs from the normal frequency reference (b1-01). 1: Speed - Both Dir. The follower drive follows the master encoder speed in both direction (follower Run command direction has no effect). 2: Speed - Fwd Dir. The follower drive follows the master encoder speed only when the master is running in the forward direction. Follower direction is determined by follower Run command direction. 3: Speed Abs Val. The follower drive follows the master encoder speed but ignores the master encoder direction (motion is always in the direction of the follower Run command). 4: Elec Line Shaft. The follower drive follows the master encoder speed and position (both directions). A reverse Run command is treated as a forward Run command; there is no directional effect. 5: ELS - Sign Run. The follower drive follows the master encoder speed and position (both directions). When a forward Run command is present the drive follows the master in the same direction. When a reverse Run command is present the drive follows in the opposite direction of the master.	Default: 0 Range: 0 to 5
P1-02	Replaced by F1-31		
P1-03 (602) RUN	Ratio Numerator (Upper 4 Digits) (Ratio Num High)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM** CLV/PM Sets the upper four digits of the primary gear ratio numerator.	Default: 1000 Min: 0 Max.: 9999

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P1-04 (603) RUN	Ratio Denominator (Upper 4 Digits) (Ratio Den High)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM** CLV/PM Sets the upper four digits of the primary gear ratio denominator.	Default: 1000 Min: 0 Max.: 9999
P1-05 (604) RUN	Ratio Numerator (Lower 4 Digits) (Ratio Num Low)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM** CLV/PM Sets the lower four digits of the primary gear ratio numerator.	Default: 0 Min: 0 Max.: 9999
P1-06 (605) RUN	Ratio Denominator (Lower 4 Digits) (Ratio Den Low)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM** CLV/PM Sets the lower four digits of the primary gear ratio denominator.	Default: 0 Min: 0 Max.: 9999
P1-07 (606) RUN	Ratio 2 Numerator (Ratio 2 Num)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the numerator of the secondary gear ratio. Active when a multi-function digital input is set to 81 (Ratio 2 Select) and the input is closed.	Default: 1 Min: 1 Max.: 65535
P1-08 (607) RUN	Ratio 2 Denominator (Ratio 2 Den)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the numerator of the secondary gear ratio. Active when a multi-function digital input is set to 81 (Ratio 2 Select) and the input is closed.	Default: 1 Min: 1 Max.: 65535
P1-09 (608)	Position Error Accumulation Selection (Pos Accum Select)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects when the position error accumulator is enabled in the follower drive. 0: Only During Run. Position error is only calculated when the follower drive is running (not during High-Slip Braking). 1: Always. Position error is calculated whenever power is applied to the drive. **Note:** ELS modes only.	Default: 0 Range: 0, 1
P1-10 (609) RUN	Position Units Selection (Position Units)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects the units used for the follower drive Position Error Monitor (U7-08). 0: Encoder Counts. Position error is displayed in quadrature follower encoder counts (cnts). 1: Motor Revs. Position error is displayed in follower motor revolutions (0.001 rev). 2: Motor Degrees. Position error is displayed in follower motor degrees (0.1 degree). 3: Motor Radians. Position error is displayed in follower motor radians (0.001 rad). **Note:** ELS modes only.	Default: 0 Range: 0 to 3
P2-01 (60A) RUN	Digital Ratio Adjustment (Digital RatioAdj)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the digital gear ratio adjustment of the follower drive. The gear ratio adjustment is also influenced by the analog, MOP, and communication gear ratio adjustments.	Default: 0.00% Min: -99.99 Max.: 65535
P2-02 (60B) RUN	MOP Adjust Time (MOP Adjust Time)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the time for the MOP ratio adjustment to change by 100.00% when the MOP Adjust Increase or MOP Adjust Decrease multi-function input is closed.	Default: 50.0 s Min: 0.0 Max.: 6000.0
P2-03 (60C) RUN	Gear Ratio Adjustment Ramp Time (Ratio Adj Ramp)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the time for the composite gear ratio adjustment of the follower drive to change by 100.00%.	Default: 10.0 s Min: 0.0 Max.: 6000.0

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P2-04 (60D)	Advance/Retard Mode Selection (Adv/Ret Mode Sel)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects the advance/retard functionality of the follower drive. 0: Continuous. The follower will advance or retard continuously while the Advance Follower or Retard Follower multi-function input is closed. Parameter P2-05 sets the amount of advance/retard encoder counts per second. 1: Step. The follower will advance or retard by the amount set in parameter P2-05 each time the Advance Follower or Retard Follower multi-function input is closed. **Note:** ELS modes only.	Default: 0 Range: 0, 1
P2-05 (60E) RUN	Advance/Retard Amount (Adv/Ret Amount)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the number of quadrature follower encoder counts the follower will advance or retard per second when parameter P2-04 is set to 0. Sets the step amount of the advance/retard function when P2-04 is set to 1. **Note:** ELS modes only.	Default: 2048 cnts Min: 0 Max.: 65535
P2-06 (60E)	Follower Deviation Level (Follower Dev Lvl)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the amount of position error in quadrature follower encoder counts that will activate the follower deviation detection. **Note:** ELS modes only.	Default: 4096 cnts Min: 0 Max.: 65535
P2-07 (610)	Follower Deviation Selection (Follower Dev Sel)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects the follower drive action when the position error exceeds the P2-06 setting. 0: No Detection. The drive continues to run. 1: Alarm Only. The drive continues to run and an FdEv alarm flashes on the digital operator. 2: Coast to Stop (Fault). The FdEv fault is displayed, the drive contact is activated, and the motor coasts to stop.	Default: 2 Range: 0 to 2
P2-08	No longer required		
P2-09 (612)	MOP Adjustment Memorization at Power Off (MOP mem @ Pwr Off)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects whether the MOP gear adjustment is memorized when the drive loses power. 0: Disabled. MOP adjustment is not memorized at power down. 1: Enabled. MOP adjustment is memorized at power down.	Default: 0 Range: 0, 1
P3-01 (614) RUN	Position P Gain (Position P Gain)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the proportional gain of the position regulator PI loop. **Note:** ELS modes only.	Default: 5.00 Min: 0.00 Max.: 100.00
P3-02 (615) RUN	Position I Time (Position I Time)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the integral time of the position regulator PI loop. **Note:** ELS modes only.	Default: 0.00 s Min: 0.00 Max.: 50.00
P3-03 (616) RUN	Position Regulator Filter Time (Pos Filter Time)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the filter time of the position regulator output. This is a first order lag filter. **Note:** ELS modes only.	Default: 0.00 s Min: 0.00 Max.: 1.50

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P3-04 (617) RUN	Position PI Limit (Pos PI Limit)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the limit (+/-) of the position regulator output as a percentage of the maximum output frequency (E1-04). **Note:** ELS modes only.	Default: 8.00% Min: 0.00 Max.: 10.00
P3-05 (618) RUN	Position Regulator Trim Mode (Pos Trim Mode)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects how the position regulator output is used to trim the follower drive speed reference (master encoder frequency). 0: Constant. The position regulator output is independent of the master encoder speed reference. 1: Speed Prop. The position regulator output is proportional to the master encoder speed reference. **Note:** ELS modes only.	Default: 0 Range: 0, 1
P3-06 (619) RUN	Speed Proportional Position Trim Lower Limit (SpdProp LowerLim)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the lower limit of the position regulator trim when P3-05 is set to 1. Set in terms of percentage of follower reference after gear ratio adjustment. *Refer to Function Description on page 16* for examples of how this factors into calculations.	Default: 10.00% Min: 0.00 Max.: 100.00
P3-07 (61A) RUN	Ratio Change Speed Agree Width (RatioChg SpdAgrF)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the frequency width used to determine “Speed Agree” when the drive is accelerating or decelerating due to one of the following factors: Gear ratio change Change in state of the Follower Disable multi-function input Change in the state of the Run command.	Default: 0.5 Hz Min: 0.0 Max.: 20.0

Table 4 Function Group Text

Function Group	Function Group Name (Digital Operator Display)
P	Coordinated Motor (Coordinated Motor)

Table 5 Function Text

Function No.	Function Name (Digital Operator Display)
P1	Follower Configuration (Follower Config)
P2	Follower Motor Tuning (Follower Tuning)
P3	Position Regulator Tuning (Pos Reg Tuning)

Table 6 Monitor Group Text

Monitor Group	Monitor Name (Digital Operator Display)	Description
U7	Coordinated Motor Monitor Group (CoordinatedMotor)	Coordinated Motor state indicators

Table 7 Monitors

No. (Addr. Hex)	Monitor Name (Digital Operator Display)	Description	Analog Output Scaling	Unit
U7-02 (661)	Master Encoder Reference (Master PG Fref)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the frequency of the master encoder before gear ratios and MOP gains are applied. **Note:** Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-03 (662)	Follower Reference after Gear Ratio (Fref After Gear)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the frequency of the master encoder after the active gear ratio (P1-03 to P1-08) is applied. **Note:** Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: 100.00%	0.01%
U7-04 (663)	Gear Ratio Adjustment (Gear Ratio Adj)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the total gear ratio adjustment (sum of the digital, analog, MOP, and communication adjustments).	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-05 (664)	Follower Reference after Gear Ratio Adjustment (Fref After Adj)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the frequency of the master encoder after the digital, analog, MOP, and communication gear ratio adjustments are applied. **Note:** Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-06 (665)	Master Counts/5ms (Master Cts/5ms)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the number of quadrature encoder counts per 5 ms from the master drive. This monitor is representative only and should only be used to confirm that encoder counts are being received. **Note:** ELS modes only.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	cnts
U7-07 (666)	Follower Counts/5ms (Follower Cts/5ms)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the number of quadrature encoder counts per 5 ms from the follower drive. This monitor is representative only and should only be used to confirm that encoder counts are being received. **Note:** ELS modes only.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	cnts
U7-08 (667)	Position Error (Position Error)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the position error between the master and follower encoders in quadrature follower encoder counts. **Note:** ELS modes only. **Note:** Modbus values are limited to -3276.8 to 3276.7. Display values are limited to -9999 to 99999 <1>.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	P1-10 <2> <3>
U7-09 (668)	Position Regulator P Output (Position P Out)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the proportional gain contribution of the position PI regulator. **Note:** ELS modes only.	Full scale: 100.00%	0.01%
U7-10 (668)	Position Regulator I Output (Position I Out)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Displays the output of the integrator of the position PI regulator. **Note:** ELS modes only.	Full scale: 100.00%	0.01%

No. (Addr. Hex)	Monitor Name (Digital Operator Display)	Description	Analog Output Scaling	Unit
U7-11 (668)	Position Regulator PI Output (Position PI Out)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the output of the position PI regulator. **Note:** ELS modes only.	Full scale: 100.00%	0.01%

<1> When the internal value is outside of the maximum/minimum value range that can be displayed on the keypad, the monitor will display the maximum/minimum value and the display name of the monitor will flash, alternating between "OVER" and the monitor name.
<2> Unit is dependent on the setting of the Position Units Selection (P1-10).
<3> When reading by network communication (register 667), the unit is fixed at quadrature encoder counts.

Table 8 MEMOBUS Registers

MEMOBUS Address	Description	Scaling
00DH	Network Communication Gear Ratio Adjustment. Allows gear ratio adjustment via network communication. The total gear ratio adjustment is the sum of the analog, digital, MOP, and network communication ratio adjustments. Data is interpreted as signed, so the adjustment can be set from -327.67% to 327.67%. **Note:** The ENTER command is not required when writing to this register.	1 = 0.01%
00EH	Network Communication Advance/Retard Counts. Allows for advancing/retarding of the follower drive via network communication. Data is interpreted as signed, so the advance/retard counts can be set from –32768 to 32767. This is set in quadrature follower encoder counts. After this register is set, its data returns to zero automatically. **Note:** ELS modes only. **Note:** The ENTER command is not required when writing to this register.	1 = 1 quadrature encoder count

Table 9 Multi-Function Output Settings (H1-☐☐)

Setting	Description
80	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Follower Disable Closed: Follower mode (P1-01) is disabled and the follower drive will follow the normal frequency reference (based on b1-01 setting) and use the selected Accel/Decel times. **Note:** ELS modes only.
81	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Ratio 2 Select Closed: Gear Ratio 2 (P1-07 and P1-08) is selected. When in ELS mode (P1-01 is set to 4 or 5), the follower drive will clear its position error and follow the C1-03 and C1-04 Accel/Decel times to ramp to the new ratio. Upon reaching speed agree, the position loop will re-enable.
82	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Advance Follower Closed: Follower position is advanced relative to the master encoder. No position error is accumulated. Refer to the descriptions for parameters P2-04 and P2-05 for details. **Note:** ELS modes only.
83	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Retard Follower Closed: Follower position is retarded relative to the master encoder. No position error is accumulated. Refer to the descriptions for parameters P2-04 and P2-05 for details. **Note:** ELS modes only.

Setting	Description
84	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** MOP Adjust Increase (MOP Adjust Inc) Closed: The MOP ratio adjustment is increased. Refer to the descriptions for parameters P2-02 and P2-09 for details.
85	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** MOP Adjust Decrease (MOP Adjust Dec) Closed: The MOP ratio adjustment is decreased. Refer to the descriptions for parameters P2-02 and P2-09 for details.
86	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** MOP Adjust Reset (MOP Adjust Reset) Closed: The MOP ratio adjustment is reset to zero. Refer to the descriptions for parameters P2-02 and P2-09 for details.
87	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Position Error Reset (Pos Err Reset) Closed: Position error is reset to zero. **Note:** ELS modes only.
88	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Position Regulator Integral Reset (Pos Reg I Reset) Closed: Position regulator integral is reset to zero. **Note:** ELS modes only.

Table 10 Multi-Function Output Settings (H2-☐☐)

Setting	Description
40	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Follower Position Deviation Closed: The position error has exceeded the Follower Deviation Level (P2-06). **Note:** ELS modes only.

Table 11 Multi-Function Analog Input Settings (H3-02/H3-06/H3-10)

Setting	Description	Analog Output Scaling
20	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Analog Ratio Adjustment Input value is added to the digital, MOP, and network communication ratio adjustments to form the total gear ratio adjustment.	Full scale: 100.00%

◆ Troubleshooting

Table 12 Fault Displays, Causes, and Possible Solutions

Digital Operator Display	Description
oPE12 PG Opt Card Err	An additional encoder card is required in the appropriate slot(s) for the selected ELS mode (P1-01) and follower control mode (A1-02).
Cause	**Possible Solution**
P1-01 is set to 4 or 5 (ELS modes) and two PG-X3 or PG-B3 option cards are not installed in the CN5-B and CN5-C ports.	Install the encoder (PG) option card into the appropriate option card slot(s). Select the appropriate ELS mode (P1- 01).
P1-01 is set to 1, 2, or 3 and a PG-X3 or PG-B3 option card is not installed in the CN5-B port.	

Digital Operator Display	Description
Digital Operator Display	**Description**
oPE21 PG Sel Err	The selected ELS mode (P1-01) requires AB Pulse detection.
Cause	**Possible Solution**
P1-01 is set to 4, 5 (ELS modes) and master or follower encoder input is set to single channel (F1-21 or F1-37 are set to 0).	Select AB Pulse detection for the appropriate channel(s) (F1-21 or F1-37 is set to 1) or select the appropriate ELS mode (P1-01).
P1-01 is set to 1 and the master encoder input is set to single channel (F1-37 is set to 0)	
Digital Operator Display	**Description**
FdEv Follower Pos Dev	The position error has exceeded the Follower Deviation Level (P2-06) and the Follower Deviation Selection (P2-07) is set to 2 (Coast to Stop).
Cause	**Possible Solution**
Mechanical binding of the follower motor.	Confirm the machinery is operating correctly and the follower motor is not binding.
The Follower Deviation Level (P2-06) is too low.	Increase the P2-06 setting.
The master encoder is rotating, the follower is stopped, and the Position Error Accumulation Selection (P1-09) is set to 1 (error is always accumulated).	If the application requires that the master encoder rotate while the follower is stopped, set P1-09 to 0 (position error only during Run).
The master input frequency is greater than the follower maximum frequency (E1-04).	Set E1-04 to a value that is 10% faster than the maximum master input frequency.
Digital Operator Display	**Description**
PL Loss of Position	The follower drive has lost its position information due to one of the following conditions: • The position error has exceeded 268,435,456 counts • The pulse frequency after the gear ratio is so high that the follower cannot run at this speed without exceeding the encoder option card hardware limitation (300 kHz).
Cause	**Possible Solution**
Mechanical binding of the follower motor.	Confirm the machinery is operating correctly and the follower motor is not binding.
The master encoder is rotating, the follower is stopped, and the Position Error Accumulation Selection (P1-09) is set to 1 (error is always accumulated).	If the application requires that the master encoder rotate while the follower is stopped, set P1-09 to 0 (position error only during Run).
The desired follower speed is too high for the PPR of the installed encoder.	Replace the encoder of the follower motor with a lower PPR model.

◆ Function Description

When parameter P1-01, Follower Mode Selection, is set to 1, 2, or 3 (speed follower mode), the drive will follow the speed of the master encoder signal. The direction that the drive runs is determined on the Run command direction and the master encoder direction, similarly to when the drive operates from a bipolar analog frequency reference.

Using the gear ratio parameters P1-03 to P1-06, the drive can be made to run at a ratio of the master speed and the alternate gear ratio (P1-07 and P1-08) can be selected using the Ratio 2 Select multi-function input (H1-0☐ = 81). The basic gear ratio formula is:

Follower Frequency Reference = Master Encoder Frequency Reference x (Numerator / Denominator)

The Master Encoder Frequency Reference formula is:

$$\frac{\text{Master Encoder Pulse Frequency}}{\text{Master Encoder PPR (F1-31)}} \times \frac{\text{Follower Motor Poles (E2-04)}}{2} = \text{Master Encoder Frequency Reference (U7-02)}$$

Figure 3 Master Encoder Frequency Reference Formula

The formula for the primary gear ratio is:

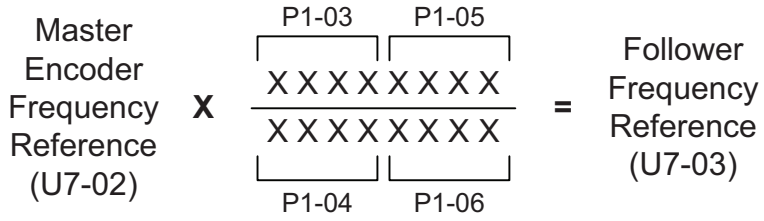


Figure 4 Primary Gear Ratio Formula

The pairs of numerator and denominator parameters are used together to form an 8-digit number divided by an 8-digit number. Use P1-03/P1-04 for ratios that can be expressed using 4-digit numbers or fewer. Gear ratio 2 can only be expressed as a 4-digit number divided by a 4-digit number.

The gear ratio required for the application must be able to be exactly expressed (including the complete remainder) by the formula in ***Figure 4***. If the ratio cannot be exactly expressed, the follower will drift in phase over time. The Simple Automatic Alignment function can be used to correct for drift over time if alignment sensors such as proximity sensors from both the master and follower systems are available as digital inputs to the follower drive.

If necessary, the ratio can be further adjusted using the Digital Ratio Adjustment, the Analog Ratio Adjustment (H3-02/06/10 = 20), the MOP Adjust multi-function inputs (H1-0☐ = 84 to 86), and the Communication Ratio Adjustment (register 00DH). These adjustments are summed and then added to 100% to produce the total gear ratio adjustment, which is multiplied by the incoming master speed reference (after gear ratio calculation).

When parameter P1-01, Follower Mode Selection, is set to 4 or 5 (ELS modes), the drive will track follower position relative to the master encoder. A PI regulator is applied to the position error. The PI regulator output trims the speed reference calculated from the master encoder signal, gear ratio parameters, and gear ratio adjustment to synchronize the position of the follower motor with the position of the master. The Advance Follower (H1-0☐ = 82) and Retard Follower (H1-0☐ = 83) multi-function inputs can also be used to change the position of the follower relative to the master.

When the gear ratio of the drive is changed during run by changing the gear ratio parameters during run or because of a change of state of the Ratio 2 Select multi-function input, the drive will ramp to the new ratio using Accel/Decel Time 2 (C1-03/C1-04). If an ELS mode is selected, the position error will be held to zero during the ratio change until the drive re-enters Speed Agree (based on setting of P3-07, Ratio Change Speed Agree Width).

When parameter P1-01, Follower Mode Selection, is set to 4 (standard ELS mode), the follower motor direction is always the same as the master encoder direction. Forward and reverse Run commands are treated identically. When P1-01 is set to 5 (Sign Run mode), the drive behaves identically to when P1-01 is set to 4, except that when a reverse Run command is given it will cause the follower drive to match speed and position in the opposite direction of the master. ***Table 13*** shows the direction of the Follower depending on the direction of the Master, P1-01 setting, b1-04 (Reverse Operation Prohibit Selection) setting, and the Forward Run/Reverse Run digital input signal.

Table 13 Follower Rotation Direction for Various Settings and Master Direction

b1-04 (Reverse Operation)	Digital Input Signal	P1-01 = 1 Speed Follower - Both Directions		P1-01 = 2 Speed Follower - Forward Direction		P1-01 = 3 Speed Follower - Absolute Value		P1-01 = 4 Electronic Line Shaft		P1-01 = 5 Electronic Line Shaft -Sign Run	
		Master: FWD	Master: REV	Master: FWD	Master: REV	Master: FWD	Master: REV	Master: FWD	Master: REV	Master: FWD	Master: REV
b1-04 = 0 Enabled	FWD	FWD	REV	FWD	NONE	FWD	FWD	FWD	REV	FWD	REV
	REV	REV	FWD	NONE	REV	REV	REV	FWD	REV	REV	FWD
b1-04 = 1 Enabled	FWD	FWD	NONE	FWD	NONE	FWD	FWD	FWD	NONE	FWD	NONE
	REV	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE

In the Standard ELS mode, when an Advance Follower input (H1-0☐ = 82) is active, the follower drive moves in the absolute positive direction with respect to the follower and in the absolute negative direction when Retard Follower input is active.

These functions behave the same way in ELS - Sign Run mode when a forward Run command is given. When a reverse Run command is given during ELS - Sign Run mode, the Advance Follower input will move the follower drive in the absolute negative direction while the Retard Follower input will move the follower drive in the absolute positive direction.

The diagrams below outline the Follower direction and Advance/Retard behavior for P1-04 settings and Forward/Reverse Run command selections

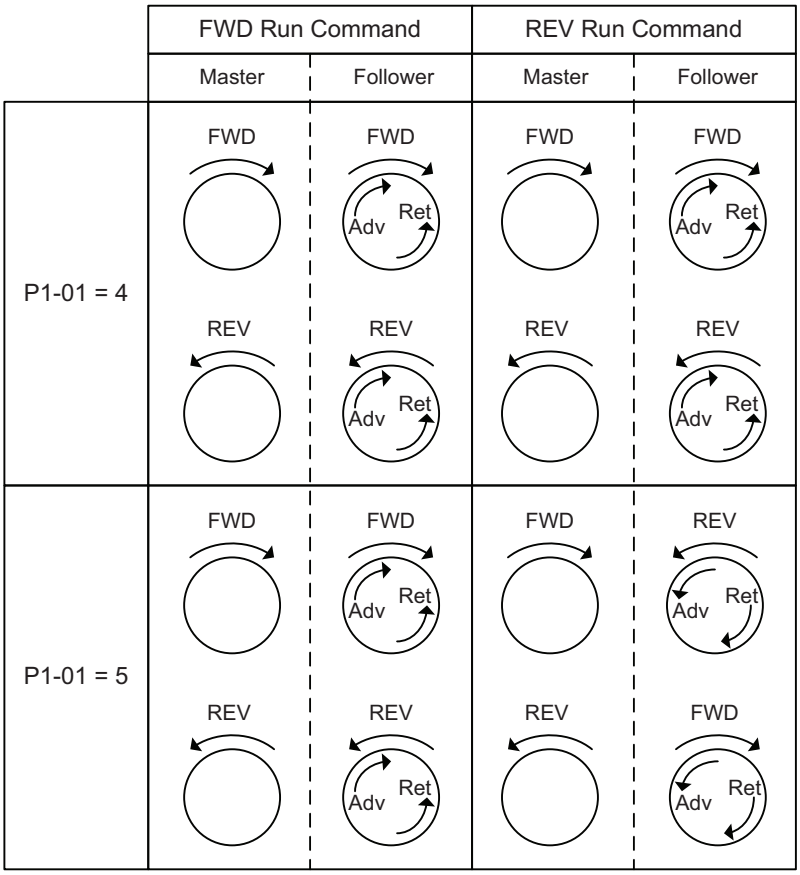


Figure 5 Follower Direction and Advance/Retard Behavior

When the drive is put into LOCAL mode (digital input or keypad button) or when the drive is given a forward or reverse jog command, the frequency reference switches back to standard frequency reference and uses the selected Accel/Decel times.

- In ELS mode, the Position P Gain setting (P3-01) is scaled in relation to the drive Max Frequency (E1-04). If the E1-04 setting is changed, the proportional contribution of the position regulator will be influenced. (The integral contribution is also influenced since it is directly proportional to the proportional contribution).
- The Maximum Output Frequency (E1-04) of the follower drive must be set higher than the maximum input frequency from the master source for proper position control. As a general rule, set E1-04 in the follower to be 10% (or at least equal to P3-04 Position PI Limit) greater than the maximum input frequency of the master source. Failure to do so can result in large continuous amounts of Position Error (U7-08).
- The exact gear ratio (including remainder) must be known and able to be expressed using the gear ratio parameters. Any error in the gear ratio settings will result in follower motor drift.

- P3-06, Speed Proportional Position Trim Lower Limit, Examples. For the following, assume E1-04 is set to 60 Hz and P3-06 is set to 10.00%:
  With Speed Proportional Position Trim disabled, a PI output of 10% adds 60 Hz * 10% = 6 Hz, regardless of the value of follower reference after gear ratio.
  With Speed Proportional Position Trim enabled, and follower reference after gear ratio of 30 Hz, a PI output of 10% adds 60 Hz * 10% * (30 Hz / 60 Hz) = 3 Hz.
  With Speed Proportional Position Trim enabled, for any follower reference below the P3-06 value multiplied by E1-04 (10% * 60 Hz = 6 Hz), the trim amount is limited to P3-06.
  In this case, a PI output of 10% adds 60 Hz * 10% * 10% = 0.6 Hz.

◆ Block Diagram

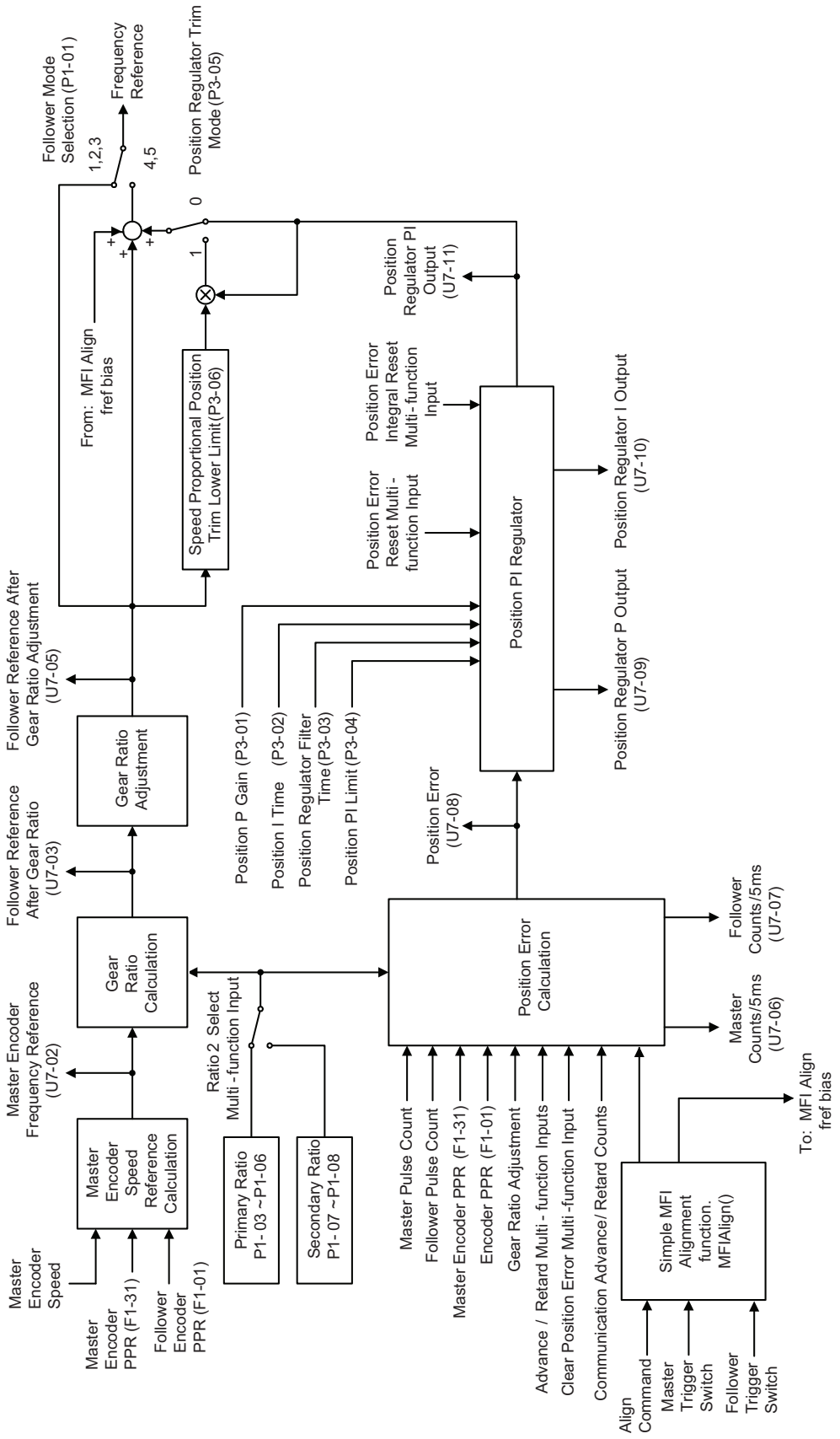


Figure 6 Software Overview Diagram

3 Simple Automation Alignment

◆ Basic Concepts and Principles

This software adds an automatic alignment feature to the base electronic line shaft software by using two proximity switches connected to the trigger inputs on the follower drive. One switch indicates the position of the master, and the other switch indicates the position of the follower. When the alignment feature is activated and the machine is running, the distance between the trigger switches is measured and then compensated for.

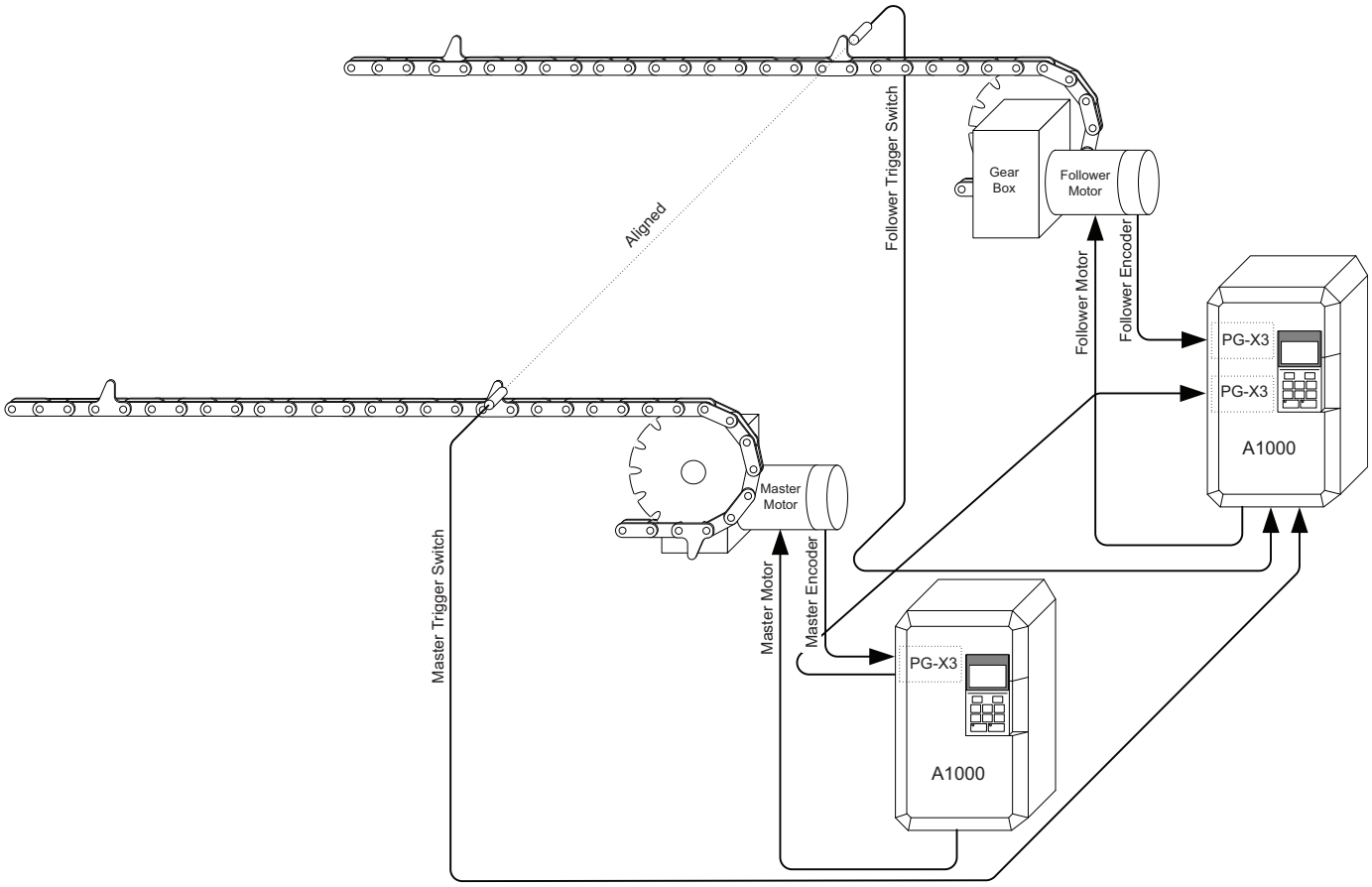


Figure 7 Simple Automation Alignment Diagram

◆ Limitations

- Alignment accuracy is decreased at higher speeds due to latency in the trigger switches and the drive digital inputs and internal scan rate.
- If the “Clear Position Error” digital input is activated when an alignment is being performed, the drive may experience a step-change in frequency reference.
- The LED keypad is not officially supported because some alarms and faults may not display properly on the LED keypad.

◆ Related Parameters and Functions

Table 1 lists terms and symbols used in this section to indicate which parameters are available in which control modes.

The parameters in the tables below are used to set up the drive for operation with the software.

Table 14 Additional Parameters

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P4-01 (61E)	Alignment Select (Alignment Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the follower mode. Enables and disables the alignment feature. 0: Alignment Disabl (Alignment Disabled) 1: Manual Align 2: Auto Align at St (Auto Align at Start) 3: Continuous Align 4: Window Align	Default: 0 Range: 0 to 4
P4-02 (620) RUN	Alignment Trim Rate (Align Trim Rate)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the amount of speed added to or subtracted from the follower drive during an alignment procedure.	Default: 6.0 Hz Min: 0.1 Max.: 30.0
P4-03 (621)	Alignment Offset (Align Offset)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets an offset value to correct for the physical misalignment of the trigger inputs in terms of follower revolutions. A positive offset value signifies that the follower signal is expected before the master (assuming standard settings and forward Run command), while a negative offset value signifies that the master signal is expected before the follower signal.	Default: 0.00 rev Min: -99.99 Max.: 99.99
P4-04 (622) RUN	Alignment Check (Alignment Check)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Used with a digital output to detect if the master and the follower trigger pulses are within a preset window of follower counts. When the number of follower quadrature encoder counts between the two trigger inputs is less than this value, the “In Alignment” digital output will activate. (H2-0☐ = 42).	Default: 0 cnts Min: 0 Max.: 65535
P4-05 (623)	Trigger Switch Type (Trigger Sw Type)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the normal (not activated) state of the Master and Follower trigger switches. 0: Both NO 1: Mstr NO Folwr NC 2: Mstr NC Folwr NO 3: Both NC	Default: 0 Range: 0 to 3
P4-06 (624)	Align Fault Select (Align Fault Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the reaction of the drive when the distance (follower motor revolutions) between the two trigger inputs exceeds the P4-07 setting. 0: Disabled 1: Ignore First Trg (Ignore First Trigger) 2: Fault	Default: 0 Range: 0 to 2

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P4-07 (625)	Maximum Alignment Distance (Max Align Dist)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the maximum number of follower motor revolutions between the trigger inputs before an Alignment Fault will occur (P4-06).	Default: 1000 rev Min: 1 Max.: 5000
P4-08 (626) RUN	Maximum Alignment Speed (Max Align Speed)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the maximum follower speed allowed for an alignment to occur to prevent alignment at high speeds where accuracy is diminished. A setting of 0.0 Hz disables this function.	Default: 0.0 Hz Min: 0.0 Max.: 400.0
P4-09 (627) RUN	Align Trigger Window (Align Trg Window)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the maximum amount of alignment error allowed before the Window Counts increment (in follower revolutions). During an alignment check, if P4-09 is exceeded, the U7-13 Window Counts monitor is incremented. If the alignment error is equal to or less than the value set to P4-09, the U7-13 Window Counts monitor is decremented. **Note:** This parameter is only used when P4-01 is set to 4.	Default: 2.00 rev Min: 0.0 Max.: 100.0
P4-10 (628) RUN	Align Trigger Count (Align Trig Count)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Sets the number of Window Counts (monitor U7-13) required to trigger an alignment. **Note:** This parameter is only used when P4-01 is set to 4.	Default: 3 cnts Min: 1 Max.: 100
P4-11 (629)	Repeat Trigger Select (Repeat Trig Sel)	V/f V/f w PG OLV CLV **OLV/PM AOLV/PM CLV/PM** Selects the method for handling triggers. 0: Last Trigger. If consecutive master triggers (or follower triggers) occur before a corresponding follower trigger (or master trigger) occurs, the last master trigger (or follower trigger) is used for alignment. 1: First Trigger. If consecutive master triggers (or follower triggers) occur before a corresponding follower trigger (or master trigger) occurs, the first master trigger (or follower trigger) is used for alignment. This option is identical to F7 functionality.	Default: 0 Range: 0, 1

Table 15 Function Text

Function No.	Function Name (Digital Operator Display)
P4	Alignment Configuration (Alignment)

Table 16 Monitor Group Text

Monitor Group	Monitor Name (Digital Operator Display)	Description
U7	Coordinated Motor (CoordinatedMotor)	Contains all monitors related to Coordinated Motor functionality.

Table 17 Monitors

No. (Addr. Hex)	Monitor Name (Digital Operator Display)	Description	Analog Output Scaling	Unit
U7-12 (66C)	Alignment Error Alignment Error	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the Alignment Error seen during the last Alignment Check in follower revolutions. During default conditions with a forward Run command, a positive Alignment Error means that the master is too far ahead of the follower.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	revs
U7-13 (66D)	Alignment Window Counts Window Counts	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the current count of Alignment Checks that have been outside of the P4-09 alignment window when P4-01 is set to 4. This monitor resets and an alignment is performed when this count is reaches the value of P4-10.	n/a	n/a

Table 18 Multi-Function Output Settings (H1-☐☐)

Setting	Description
89	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Follower Trigger (Follower Trigger) This input is connected to a switch that detects the position of the follower machine. Configurable using parameter P4-05.
8A	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Master Trigger (Master Trigger) This input is connected to a switch that detects the position of the master machine. Configurable using parameter P4-05.
8B	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Advance Follower Closed: Follower position is advanced relative to the master encoder. No position error is accumulated. Refer to the descriptions for parameters P2-04 and P2-05 for details. **Note:** ELS modes only.

Table 19 Multi-Function Output Settings (H2-☐☐)

Setting	Description
41	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Align Complete Closed after a successful alignment operation completes. Open after: • The first trigger has been received and the accumulated distance exceeds the sum of P4-03 and P4-04. • The follower is stopped, faulted, or an electronic line shaft position error is cleared or disabled. • An advance/retard command is given. • The next Align Follower Command digital input is given when P4-01 is set to 1 or 2. • The next Master Trigger or Follower Trigger digital input occurs when P4-01 is set to 3 or 4.

Setting	Description
42	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM In Alignment Closed after both trigger inputs are received and the distance between them is shorter than the P4-04 value. Open after: • The first trigger has been received and the accumulated distance exceeds the sum of P4-03 and P4-04. • The follower is stopped, faulted, or an electronic line shaft position error is cleared or disabled. • An advance/retard command is given.

◆ Troubleshooting

Table 20 Fault Displays, Causes, and Possible Solutions

Digital Operator Display	Description
AF Alignment Fault	Too much distance (follower motor revolutions) was counted between the two trigger inputs during an alignment routine. The distance measured between the two trigger pulses (during alignment) or the entire alignment error (including offset and position error) has exceeded 21,474,836 encoder counts. (Regardless of the P4-07 setting).
Cause	**Possible Solution**
The distance between the master and the follower exceeded the allowable amount (P4-07).	Check the machine integrity.
Malfunctioning or miswired trigger switches.	Check the trigger switches for proper wiring and operation.

◆ Function Descriptions

■ Alignment Enable

To enable the alignment function, it is necessary to program the master and the follower trigger multi-function digital input functions into the H1-☐☐ parameters and set parameter P4-01, Alignment Select, to a non-zero value.

The alignment function will NOT operate under the following conditions:

- Drive is faulted
- Drive is not running
- Follower is ramping between forward and reverse Run commands
- Electronic Line Shaft is disabled via multi-function input (H1-☐☐ = 80)
- Electronic Line Shaft is disabled via parameter setting (P1-01 is set to 1, 2, or 3)
- Drive is in LOCAL mode
- A “Jog” is being commanded of the follower drive
- Drive is ramping to speed due to a gear ratio change or Line Shaft being re-enabled
- Position error is being cleared via multi-function input (H1-☐☐ = 87).

■ Alignment Select

Parameter P4-01, Alignment Select, enables and disables the alignment feature. When P4-01 is set to 0, the drive will not perform an alignment and the two digital outputs associated with alignment (H2-0☐ = 41 and H2-0☐ = 42) are de-energized.

- When P4-01 is set to 0 - Disabled. The drive will not perform an alignment.
- When P4-01 is set to 1 - Manual Align. The drive must see the rising edge of the align command (H1-☐☐ = 8B) to start the alignment process. The drive will not attempt another alignment until there is another rising edge on the align command.
- When P4-01 is set to 2 - Auto Align at Start. The drive will immediately begin the alignment process when the Run command is applied. The drive will not attempt another alignment until there is another rising edge on the align command.

- When P4-01 is set to 3 - Continuous Alignment. The drive will immediately begin the alignment process when the Run command is applied. When two valid trigger inputs are received, the drive automatically re-starts the alignment process. Trigger pulses will be ignored if the drive has not completed the previous alignment.
- When P4-01 is set to 4 - Window Alignment. The drive will perform an alignment at start and measure alignment during subsequent trigger pulses. When the alignment is off by more than the P4-09 setting, the U7-13 count will increment. When the alignment is within the P4-09 setting, the U7-13 count will decrement. Alignment is also performed when the U7-13 count is equal to P4-10, at which time U7-13 is reset to zero.

■ Alignment Process

The alignment function aligns the follower to the master using fixed trigger positions. This process does not control the master drive; all corrections are made by the follower drive. The amount of the correction is controlled by the quadrature counts accumulated from the time when the first or leading trigger starts the process and continues until the trailing trigger stops it and the speed of the correction is controlled by parameter P4-02, Alignment Trim Rate.

The correction is made when the trailing trigger input becomes active. The rate at which the drive accelerates or decelerates during the alignment procedure is fixed. For a 1024 PPR encoder, the ramp rate will be approximately 20Hz/1 sec. The alignment process is intended to be performed at low speeds, but will function as long as the triggers provide at least a 15 millisecond signal so the follower drive can see the trigger inputs.

Note: If consecutive master triggers occur before a follower trigger occurs, the first master trigger will be used and subsequent master triggers will be ignored. If consecutive follower triggers occur before a master trigger occurs, the first follower trigger will be used and subsequent master triggers will be ignored.

Maximum alignment speed: If an alignment is in process and the follower needs to run faster to catch up to the master, it will only be allowed to compensate at a rate of up to 95% of the follower's maximum frequency setting. If the follower is already running at or above the 95% speed level, the alignment function will not complete.

Minimum alignment speed: If an alignment is in process, and the follower needs to slow down in order for the master to catch up, the follower drive could run in reverse. If reverse on the follower is disabled (b1-04 = 1), the follower drive will only be allowed to run at a minimum of zero speed (no reverse).

■ Alignment Fault Select

When parameter P4-06 is set to 0, "Disabled", there is no settable limit to the number of follower motor revolutions that can elapse between master and follower trigger inputs.

Note: To prevent internal overflow, the maximum number of encoder counts allowed between the two trigger inputs is 268,435,456. (65,536 motor revolutions with a 1024 PPR encoder).

When parameter P4-06 is set to 1, "Ignore 1st Pulse", it will disregard the first trigger input (regardless of master or follower) when the P4-07 distance (either direction) has elapsed.

If the align command is asserted between the time that the master and follower trigger inputs are read and the P4-07 distance elapses, the drive will disregard the first input and wait for two valid trigger inputs. When using this mode, it is useful to program the P4-07 distance to between 50% and 90% of the total trigger-to-trigger distance.

When parameter P4-06 is set to 2, "Fault", the drive will fault out on an "AF - Alignment Fault" and coast to stop when the number of P4-07 revolutions have passed after the first trigger input (regardless of master or follower). When this mode is used, it is useful to set P4-07 to a value greater than the normal trigger-to-trigger distance.

■ Align Complete / In Alignment Multi-function Digital Outputs

The "Align Complete" digital output (H2-0□ = 41) will close when a successful align procedure has been completed. The Align Complete digital output will de-energize after detecting the rising edge of an Align Follower Command. If the drive is set to reset position error at stop (P1-09 = 0), the Align Complete digital output will also de-energize when the Run command is removed or if electronic line shaft is disabled (H1-□□ = 80). If the drive is set to accumulate position error at all times (P1-09 = 1), the Align Complete will de-energize only if electronic line shaft is disabled or another align command is received.

The “In Alignment” digital output (H2-0□ = 42) indicates whether the trigger inputs are activated within a settable quadrature encoder count range. The In Alignment output energizes when the triggers are within the P4-07 setting and will de-energize when the P4-07 setting is exceeded. This output will only change state after the trailing trigger has activated.

■ Position Error Clear

A condition is added to this software that will clear the position error. When parameter P1-09 is set to 0 and High Slip Braking is activated, the position error will be cleared.

◆ Diagrams

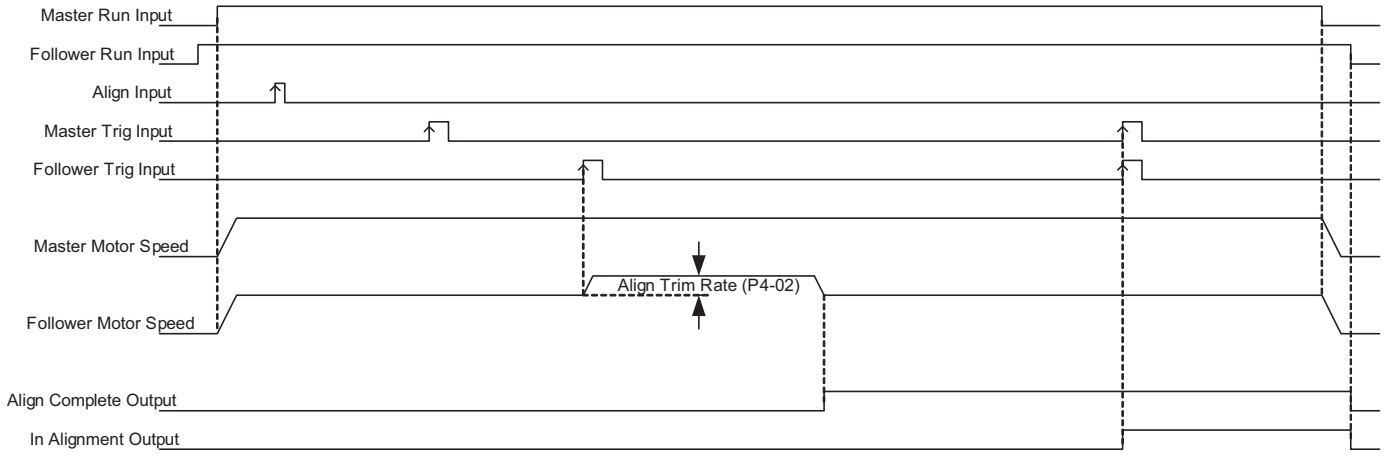


Figure 8 Forward Run - Alignment - Master before Follower

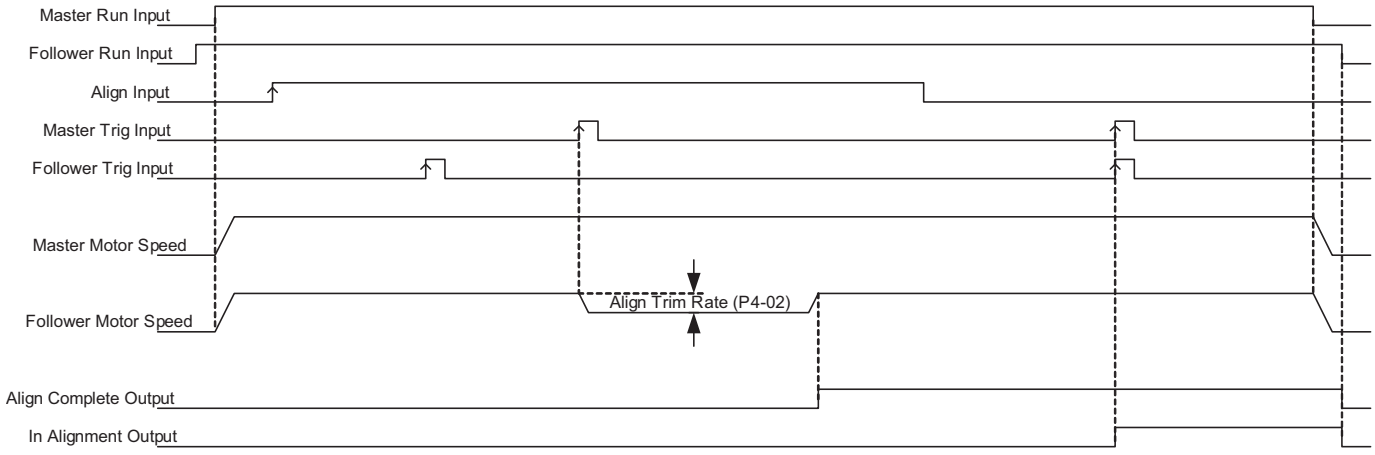


Figure 9 Forward Run - Alignment - Follower before Master

Note: The “Align Input” is edge triggered. It does not matter whether the input is maintained or momentary.

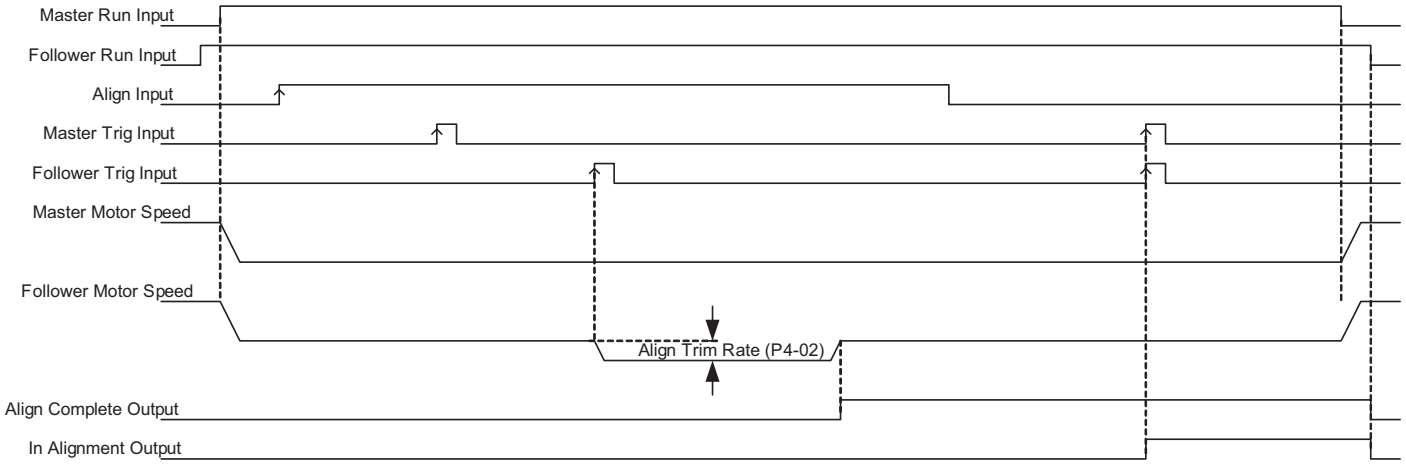


Figure 10 Reverse Run - Alignment - Master before Follower

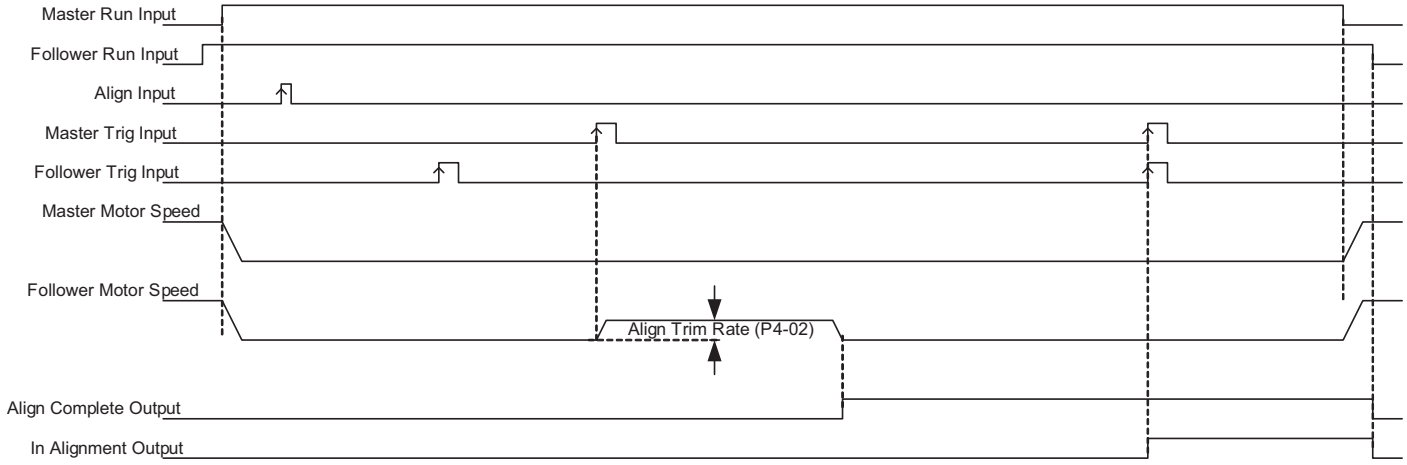


Figure 11 Reverse Run - Alignment - Follower before Master

Note: The "Align Input" is edge triggered. It does not matter whether the input is maintained or momentary.

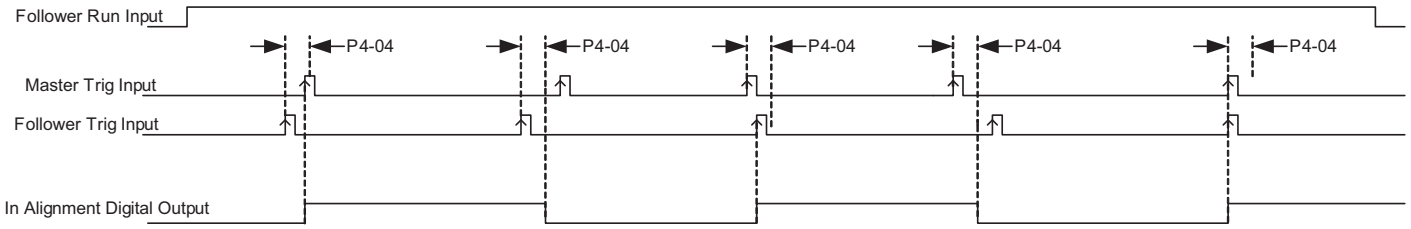


Figure 12 In Alignment (Digital Output) Function, No Offset (P4-03 = 0.00 revs) (P4-04 = 4096 cnts)

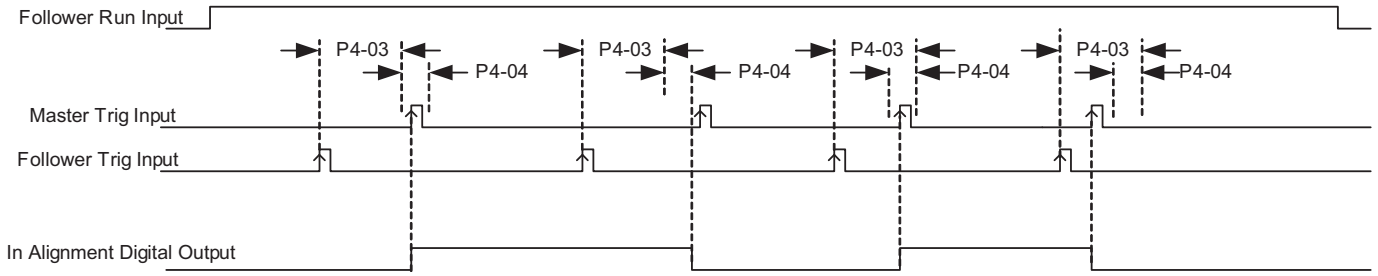


Figure 13 In Alignment (Digital Output) Function, with Offset (P4-03 = +3.00 revs) (P4-04 = 4096 cnts)

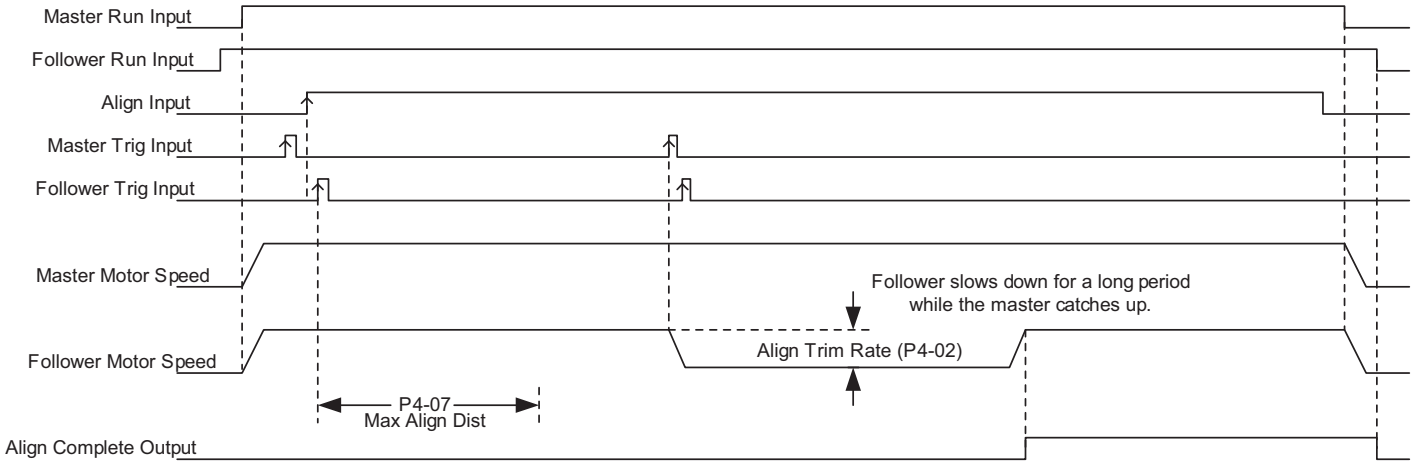


Figure 14 Alignment Fault Select = Disabled (P4-06 = 0)

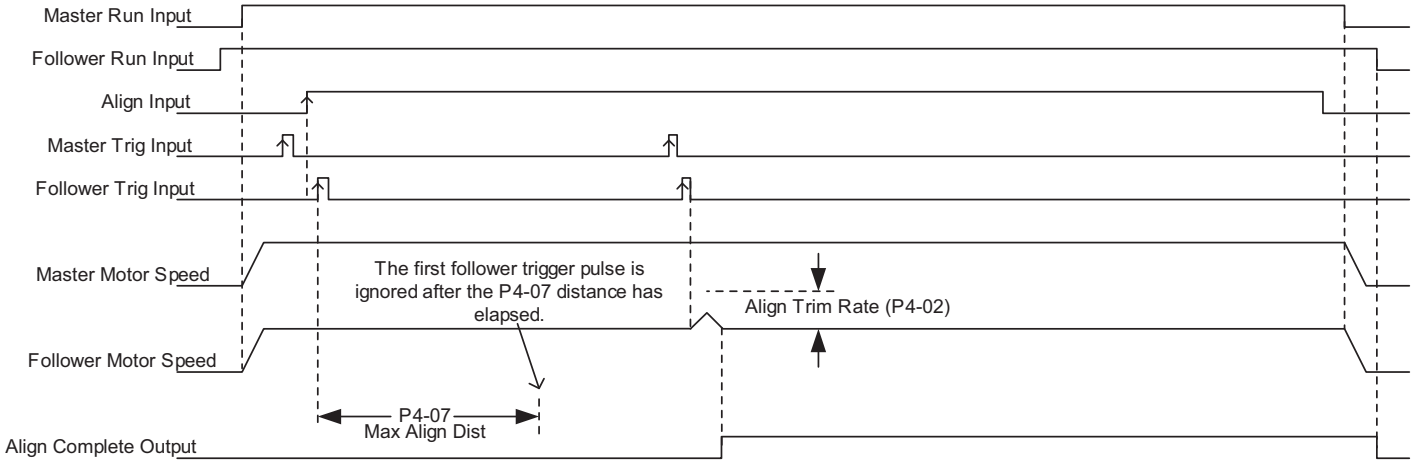


Figure 15 Alignment Fault Select = Ignore 1st Pulse (P4-06 = 1)

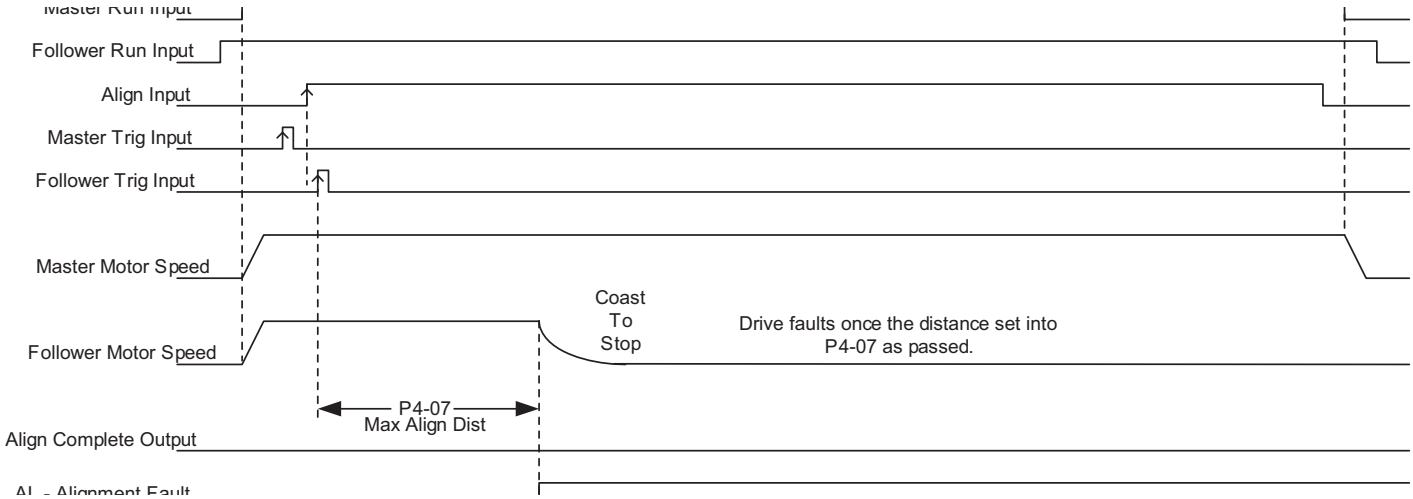


Figure 16 Alignment Fault Select = Fault (P4-06 = 2)

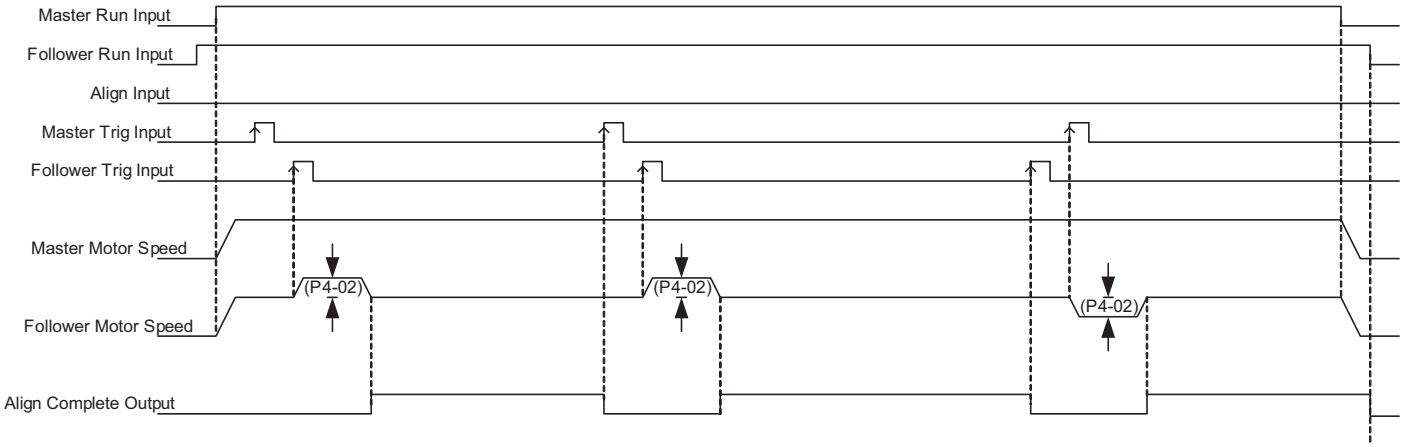


Figure 17 Continuous Alignment (P4-01 = 3)

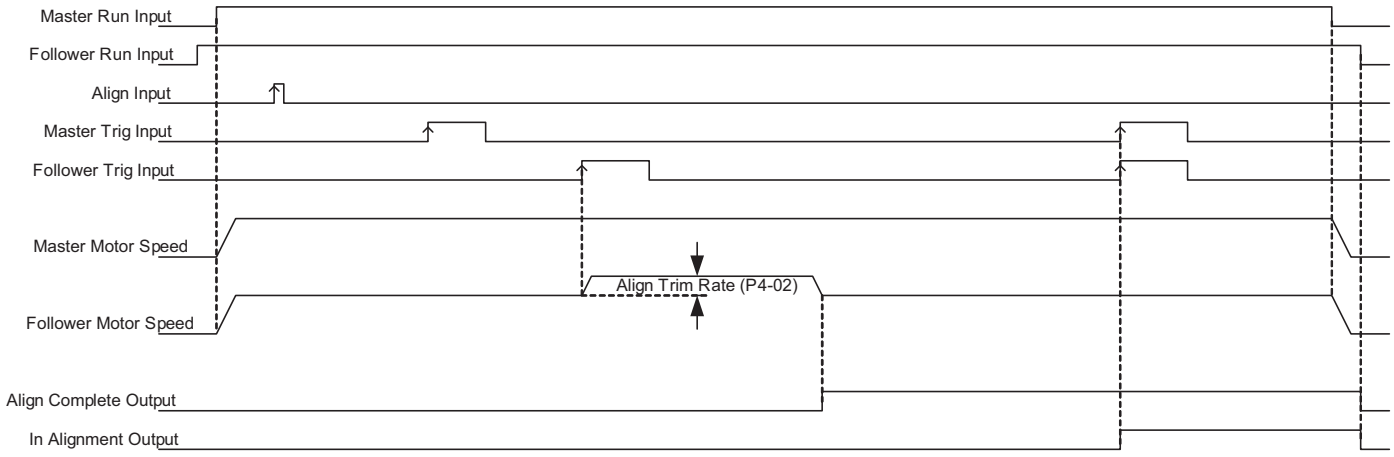


Figure 18 Normally Open Trigger Inputs (P4-05 = 0)

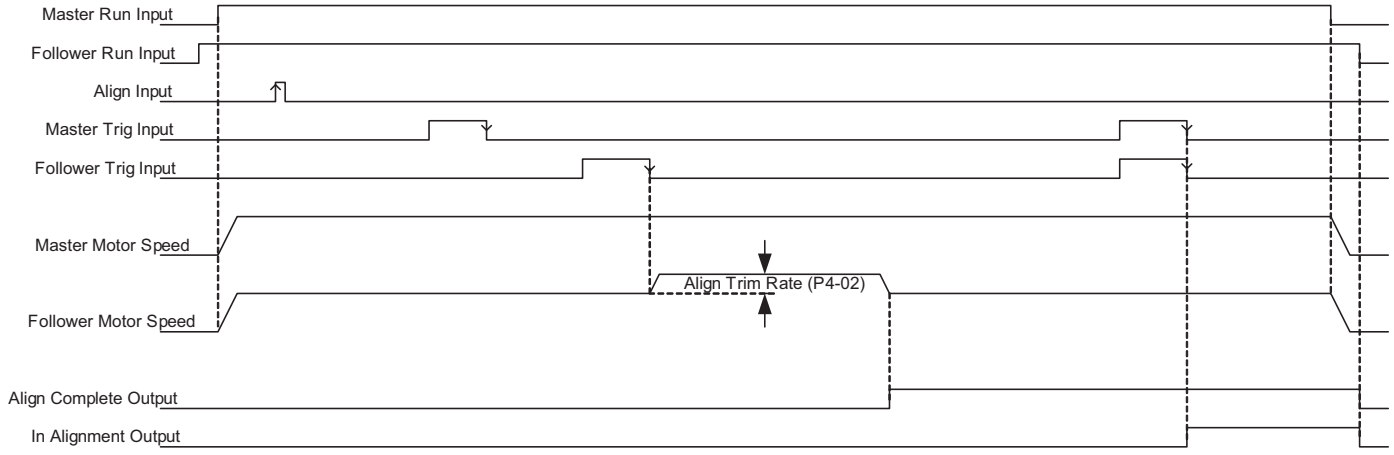


Figure 19 Normally Closed Trigger Inputs (P4-05 = 3)

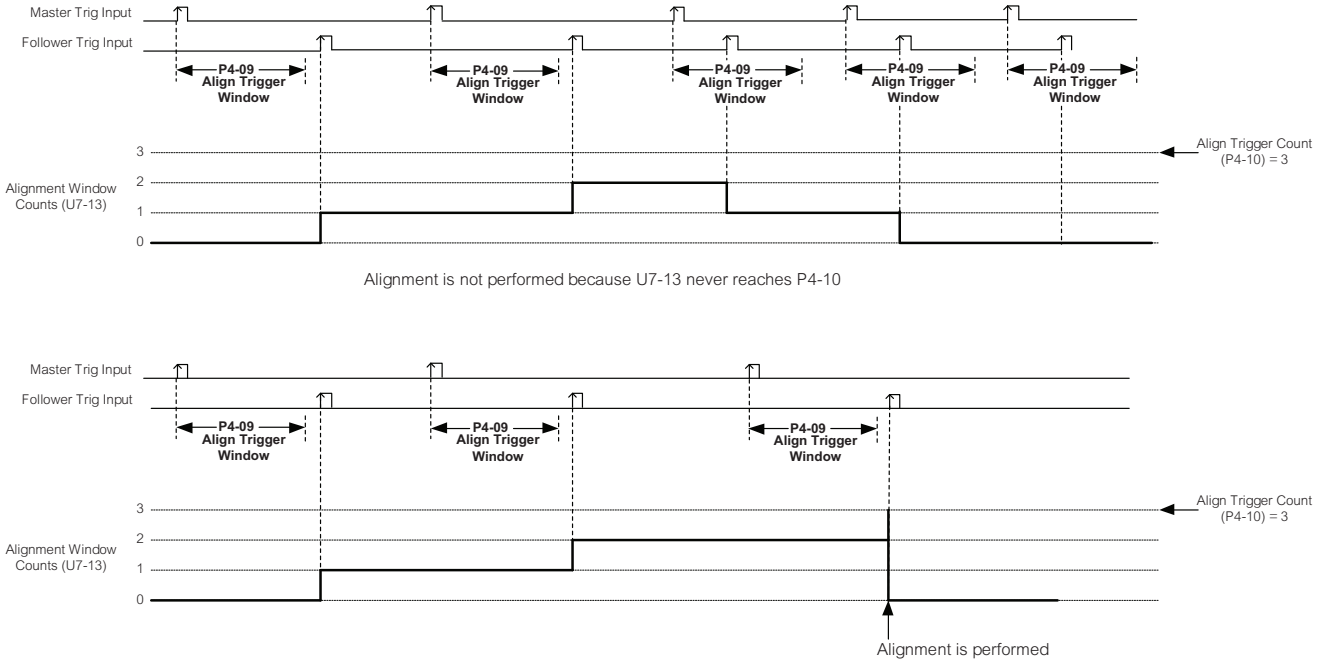


Figure 20 P4-01 = 4, Window Alignment Mode

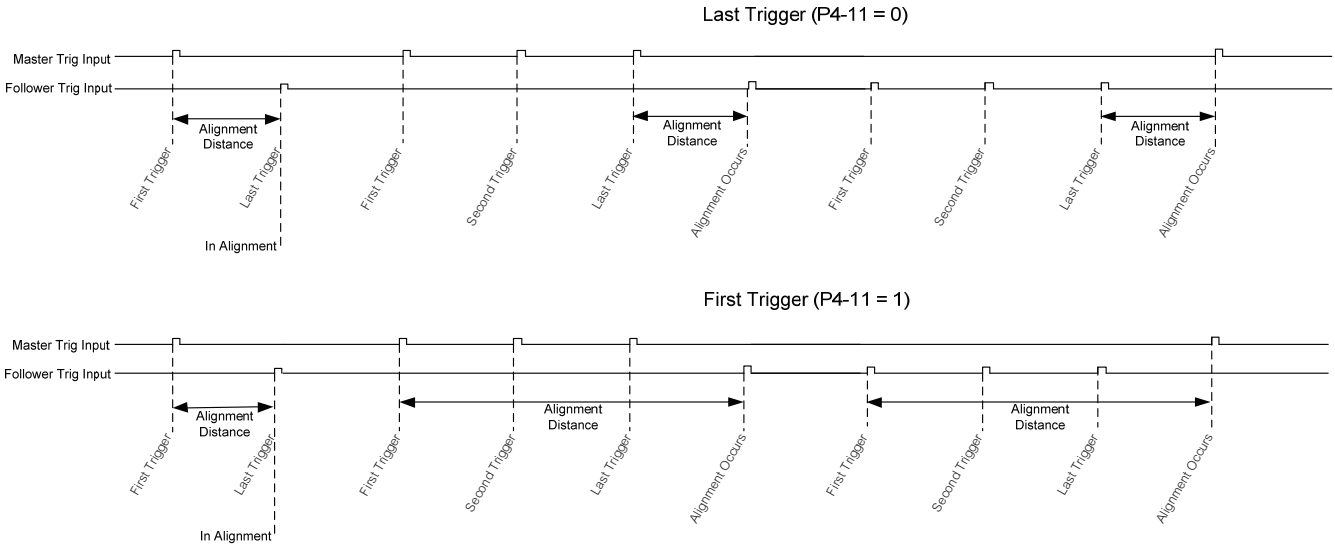


Figure 21 Last and First Triggers

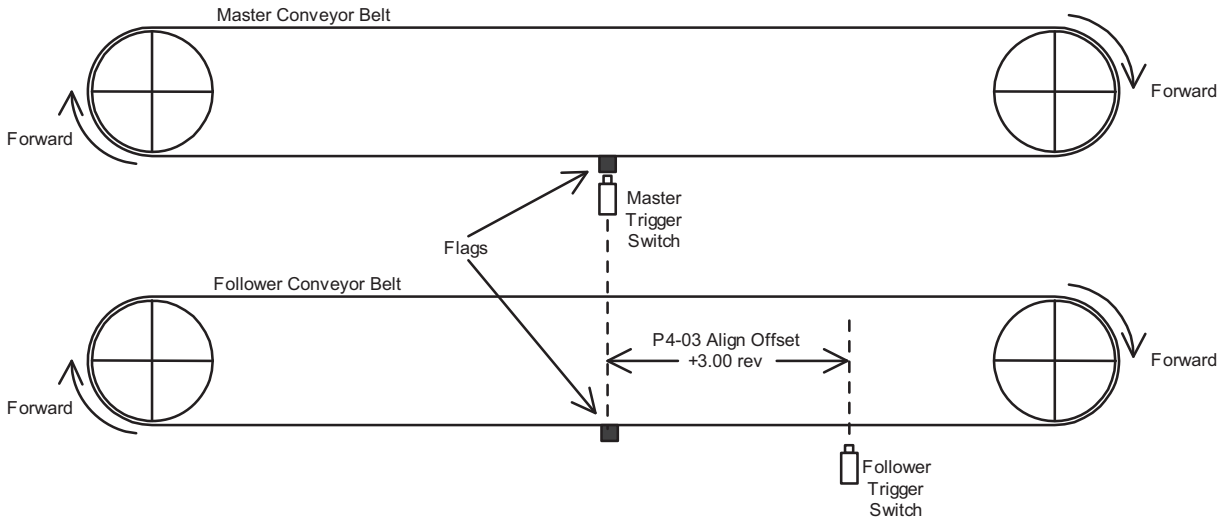


Figure 22 Two Aligned Conveyor Belts with Different Trigger Switch Positioning Corrected with Parameter P4-03

4 Comprehensive Parameter List

◆ F1: PG Speed Control Card

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
F1-01 (380)	PG1 Pulses per Revolution (PG Pulses/Rev)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the number of pulses for a PG option card connected to port CN5-C.	Default: 1024 ppr Min: 1 Max.: 60000
F1-02 (381)	Operation Selection at PG Open Circuit (PGo) (PG Fdbk Loss Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the operation when a PGo is detected on a PG option card connected to port CN5-C. 0: Ramp to Stop 1: Coast to Stop 2: Fast Stop 3: Alarm Only 4: No Alarm Display	Default: 1 Range: 0 to 4
F1-05 (384)	PG 1 Rotation Selection (PG1 Rotation Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the direction of forward travel for the PG card installed in CN5-C. 0: Pulse A Leads 1: Pulse B Leads	Default: 0 Range: 0, 1
F1-14 (38D)	PG Open-Circuit Detection Time (PGO Detect Time)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the amount of time required to trigger a PG Open fault (PGo).	Default: 2.0 s Min: 0.0 Max.: 10.0
F1-21 (3BC)	PG 1 Signal Selection (PG1 Signal Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects single-channel/quadrature detection mode for the PG option card 1. 0: A Pulse Detection 1: AB Pulse Detection	Default: 1 Range: 0, 1
F1-31 (3B0)	PG 2 Pulses per Revolution (PG Pulses/Rev 2)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the number of pulses for a PG option card connected to port CN5-B.	Default: 1024 ppr Min: 1 Max.: 60000
F1-32 (3B1)	PG 2 Rotation Selection (PG Rotation Sel2)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the direction of forward travel for a PG option card installed in port CN5-B. 0: Pulse A Leads 1: Pulse B Leads	Default: 0 Range: 0, 1
F1-36 (3B5)	PG Option Card Disconnect Detection 2 (Hardware PGO Ch2)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Determines whether the drive detects a fault when a PGo is detected on a PG option card installed in port CN5-B. 0: Disabled 1: Enabled	Default: 1 Range: 0, 1

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
F1-37 (3BD)	PG 2 Signal Selection (PG2 Signal Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects single-channel/quadrature detection mode for the PG option card 2 installed in port CN5-B. 0: A Pulse Detection 1: AB Pulse Detection	Default: 1 Range: 0, 1

◆ H1: Multi-Function Digital Input Settings

Setting	Description
80	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Follower Disable Closed: Follower mode (P1-01) is disabled and the follower drive will follow the normal frequency reference (based on b1-01 setting) and use the selected Accel/Decel times. Note: ELS modes only.
81	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Ratio 2 Select Closed: Gear Ratio 2 (P1-07 and P1-08) is selected. When in ELS mode (P1-01 is set to 4 or 5), the follower drive will clear its position error and follow the C1-03 and C1-04 Accel/Decel times to ramp to the new ratio. Upon reaching speed agree, the position loop will re-enable.
82	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Advance Follower Closed: Follower position is advanced relative to the master encoder. No position error is accumulated. Refer to the descriptions for parameters P2-04 and P2-05 for details. Note: ELS modes only.
83	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Retard Follower Closed: Follower position is retarded relative to the master encoder. No position error is accumulated. Refer to the de scrip to ins for parameters P2-04 and P2-05 for details. Note: ELS modes only.
84	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM MOP Adjust Increase (MOP Adjust Inc) Closed: The MOP ratio adjustment is increased. Refer to the descriptions for parameters P2-02 and P2-09 for details.
85	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM MOP Adjust Decrease (MOP Adjust Dec) Closed: The MOP ratio adjustment is decreased. Refer to the descriptions for parameters P2-02 and P2-09 for details.
86	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM MOP Adjust Reset (MOP Adjust Reset) Closed: The MOP ratio adjustment is reset to zero. Refer to the descriptions for parameters P2-02 and P2-09 for details.

Setting	Description
87	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Position Error Reset (Pos Err Reset) Closed: Position error is reset to zero. Note: ELS modes only.
88	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Position Regulator Integral Reset (Pos Reg I Reset) Closed: Position regulator integral is reset to zero. Note: ELS modes only.
89	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Follower Trigger (Follower Trigger) This input is connected to a switch that detects the position of the follower machine. Configurable using parameter P4-05.
8A	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Master Trigger (Master Trigger) This input is connected to a switch that detects the position of the master machine. Configurable using parameter P4-05.
8B	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Advance Follower Closed: Follower position is advanced relative to the master encoder. No position error is accumulated. Refer to the descriptions for parameters P2-04 and P2-05 for details. Note: ELS modes only.

◆ H2: Multi-Function Digital Output Settings

Setting	Description
40	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Follower Position Deviation Closed: The position error has exceeded the Follower Deviation Level (P2-06). Note: ELS modes only.
41	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Align Complete Closed after a successful alignment operation completes. Open after: The first trigger has been received and the accumulated distance exceeds the sum of P4-03 and P4-04. The follower is stopped, faulted, or an electronic line shaft position error is cleared or disabled. An advance/retard command is given. The next Align Follower Command digital input is given when P4-01 is set to 1 or 2. The next Master Trigger or Follower Trigger digital input occurs when P4-01 is set to 3 or 4.
42	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM In Alignment Closed after both trigger inputs are received and the distance between them is shorter than the P4-04 value. Open after: The first trigger has been received and the accumulated distance exceeds the sum of P4-03 and P4-04. The follower is stopped, faulted, or an electronic line shaft position error is cleared or disabled. An advance/retard command is given.

◆ H3: Multi-Function Analog Input Settings (H3-02/H3-06/H3-10)

Setting	Description	Analog Output Scaling
20	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Analog Ratio Adjustment Input value is added to the digital, MOP, and network communication ratio adjustments to form the total gear ratio adjustment.	Full scale: 100.00%

◆ P1: Follower Configuration

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P1-01 (600)	Follower Mode Selection (Follower Mode)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the follower mode. 0: Disabled. Follower mode is disabled and the follower drive runs from the normal frequency reference (b1-01). 1: Speed - Both Dir. The follower drive follows the master encoder speed in both direction (follower Run command direction has no effect). 2: Speed - Fwd Dir. The follower drive follows the master encoder speed only when the master is running in the forward direction. Follower direction is determined by follower Run command direction. 3: Speed Abs Val. The follower drive follows the master encoder speed but ignores the master encoder direction (motion is always in the direction of the follower Run command). 4: Elec Line Shaft. The follower drive follows the master encoder speed and position (both directions). A reverse Run command is treated as a forward Run command; there is no directional effect. 5: ELS - Sign Run. The follower drive follows the master encoder speed and position (both directions). When a forward Run command is present the drive follows the master in the same direction. When a reverse Run command is present the drive follows in the opposite direction of the master.	Default: 0 Range: 0 to 5
P1-02	Replaced by F1-31		
P1-03 (602) RUN	Ratio Numerator (Upper 4 Digits) (Ratio Num High)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the upper four digits of the primary gear ratio numerator.	Default: 1000 Min: 0 Max.: 9999
P1-04 (603) RUN	Ratio Denominator (Upper 4 Digits) (Ratio Den High)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the upper four digits of the primary gear ratio denominator.	Default: 1000 Min: 0 Max.: 9999
P1-05 (604) RUN	Ratio Numerator (Lower 4 Digits) (Ratio Num Low)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the lower four digits of the primary gear ratio numerator.	Default: 0 Min: 0 Max.: 9999
P1-06 (605) RUN	Ratio Denominator (Lower 4 Digits) (Ratio Den Low)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the lower four digits of the primary gear ratio denominator.	Default: 0 Min: 0 Max.: 9999
P1-07 (606) RUN	Ratio 2 Numerator (Ratio 2 Num)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the numerator of the secondary gear ratio. Active when a multi-function digital input is set to 81 (Ratio 2 Select) and the input is closed.	Default: 1 Min: 1 Max.: 65535

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P1-08 (607) RUN	Ratio 2 Denominator (Ratio 2 Den)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the numerator of the secondary gear ratio. Active when a multi-function digital input is set to 81 (Ratio 2 Select) and the input is closed.	Default: 1 Min: 1 Max.: 65535
P1-09 (608)	Position Error Accumulation Selection (Pos Accum Select)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects when the position error accumulator is enabled in the follower drive. 0: Only During Run. Position error is only calculated when the follower drive is running (not during High-Slip Braking). 1: Always. Position error is calculated whenever power is applied to the drive. Note: ELS modes only.	Default: 0 Range: 0, 1
P1-10 (609) RUN	Position Units Selection (Position Units)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the units used for the follower drive Position Error Monitor (U7-08). 0: Encoder Counts. Position error is displayed in quadrature follower encoder counts (cnts). 1: Motor Revs. Position error is displayed in follower motor revolutions (0.001 rev). 2: Motor Degrees. Position error is displayed in follower motor degrees (0.1 degree). 3: Motor Radians. Position error is displayed in follower motor radians (0.001 rad). Note: ELS modes only.	Default: 0 Range: 0 to 3

◆ P2: Follower Motor Tuning

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P2-01 (60A) RUN	Digital Ratio Adjustment (Digital RatioAdj)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the digital gear ratio adjustment of the follower drive. The gear ratio adjustment is also influenced by the analog, MOP, and communication gear ratio adjustments.	Default: 0.00% Min: -99.99 Max.: 65535
P2-02 (60B) RUN	MOP Adjust Time (MOP Adjust Time)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the time for the MOP ratio adjustment to change by 100.00% when the MOP Adjust Increase or MOP Adjust Decrease multi-function input is closed.	Default: 50.0 s Min: 0.0 Max.: 6000.0
P2-03 (60C) RUN	Gear Ratio Adjustment Ramp Time (Ratio Adj Ramp)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the time for the composite gear ratio adjustment of the follower drive to change by 100.00%.	Default: 10.0 s Min: 0.0 Max.: 6000.0

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P2-04 (60D)	Advance/Retard Mode Selection (Adv/Ret Mode Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the advance/retard functionality of the follower drive. 0: Continuous. The follower will advance or retard continuously while the Advance Follower or Retard Follower multi-function input is closed. Parameter P2-05 sets the amount of advance/retard encoder counts per second. 1: Step. The follower will advance or retard by the amount set in parameter P2-05 each time the Advance Follower or Retard Follower multi-function input is closed. Note: ELS modes only.	Default: 0 Range: 0, 1
P2-05 (60E) RUN	Advance/Retard Amount (Adv/Ret Amount)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the number of quadrature follower encoder counts the follower will advance or retard per second when parameter P2-04 is set to 0. Sets the step amount of the advance/retard function when P2-04 is set to 1. Note: ELS modes only.	Default: 2048 cnts Min: 0 Max.: 65535
P2-06 (60E)	Follower Deviation Level (Follower Dev Lvl)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the amount of position error in quadrature follower encoder counts that will activate the follower deviation detection. Note: ELS modes only.	Default: 4096 cnts Min: 0 Max.: 65535
P2-07 (610)	Follower Deviation Selection (Follower Dev Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the follower drive action when the position error exceeds the P2-06 setting. 0: No Detection. The drive continues to run. 1: Alarm Only. The drive continues to run and an FdEv alarm flashes on the digital operator. 2: Coast to Stop (Fault). The FdEv fault is displayed, the drive contact is activated, and the motor coasts to stop.	Default: 2 Range: 0 to 2
P2-08	No longer required		
P2-09 (612)	MOP Adjustment Memorization at Power Off (MOP mem @ Pwr Off)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects whether the MOP gear adjustment is memorized when the drive loses power. 0: Disabled. MOP adjustment is not memorized at power down. 1: Enabled. MOP adjustment is memorized at power down.	Default: 0 Range: 0, 1

◆ P3: Position Regulator Tuning

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P3-01 (614) RUN	Position P Gain (Position P Gain)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the proportional gain of the position regulator PI loop. Note: ELS modes only.	Default: 5.00 Min: 0.00 Max.: 100.00
P3-02 (615) RUN	Position I Time (Position I Time)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the integral time of the position regulator PI loop. Note: ELS modes only.	Default: 0.00 s Min: 0.00 Max.: 50.00

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P3-03 (616) RUN	Position Regulator Filter Time (Pos Filter Time)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the filter time of the position regulator output. This is a first order lag filter. Note: ELS modes only.	Default: 0.00 s Min: 0.00 Max.: 1.50
P3-04 (617) RUN	Position PI Limit (Pos PI Limit)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the limit (+/-) of the position regulator output as a percentage of the maximum output frequency (E1-04). Note: ELS modes only.	Default: 8.00% Min: 0.00 Max.: 10.00
P3-05 (618) RUN	Position Regulator Trim Mode (Pos Trim Mode)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects how the position regulator output is used to trim the follower drive speed reference (master encoder frequency). 0: Constant. The position regulator output is independent of the master encoder speed reference. 1: Speed Prop. The position regulator output is proportional to the master encoder speed reference. Note: ELS modes only.	Default: 0 Range: 0, 1
P3-06 (619) RUN	Speed Proportional Position Trim Lower Limit (SpdProp LowerLim)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the lower limit of the position regulator trim when P3-05 is set to 1. Set in terms of percentage of follower reference after gear ratio adjustment. *Refer to Function Description on page 16* for examples of how this factors into calculations.	Default: 10.00% Min: 0.00 Max.: 100.00
P3-07 (61A) RUN	Ratio Change Speed Agree Width (RatioChg SpdAgrF)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the frequency width used to determine “Speed Agree” when the drive is accelerating or decelerating due to one of the following factors: Gear ratio change Change in state of the Follower Disable multi-function input Change in the state of the Run command.	Default: 0.5 Hz Min: 0.0 Max.: 20.0

◆ P4: Alignment Configuration

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P4-01 (61E)	Alignment Select (Alignment Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the follower mode. Enables and disables the alignment feature. 0: Alignment Disabl (Alignment Disabled) 1: Manual Align 2: Auto Align at St (Auto Align at Start) 3: Continuous Align 4: Window Align	Default: 0 Range: 0 to 4
P4-02 (620) RUN	Alignment Trim Rate (Align Trim Rate)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the amount of speed added to or subtracted from the follower drive during an alignment procedure.	Default: 6.0 Hz Min: 0.1 Max.: 30.0

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P4-03 (621)	Alignment Offset (Align Offset)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets an offset value to correct for the physical misalignment of the trigger inputs in terms of follower revolutions. A positive offset value signifies that the follower signal is expected before the master (assuming standard settings and forward Run command), while a negative offset value signifies that the master signal is expected before the follower signal.	Default: 0.00 rev Min: -99.99 Max.: 99.99
P4-04 (622) RUN	Alignment Check (Alignment Check)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Used with a digital output to detect if the master and the follower trigger pulses are within a preset window of follower counts. When the number of follower quadrature encoder counts between the two trigger inputs is less than this value, the “In Alignment” digital output will activate. (H2-0☐ = 42).	Default: 0 cnts Min: 0 Max.: 65535
P4-05 (623)	Trigger Switch Type (Trigger Sw Type)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the normal (not activated) state of the Master and Follower trigger switches. 0: Both NO 1: Mstr NO Folwr NC 2: Mstr NC Folwr NO 3: Both NC	Default: 0 Range: 0 to 3
P4-06 (624)	Align Fault Select (Align Fault Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the reaction of the drive when the distance (follower motor revolutions) between the two trigger inputs exceeds the P4-07 setting. 0: Disabled 1: Ignore First Trg (Ignore First Trigger) 2: Fault	Default: 0 Range: 0 to 2
P4-07 (625)	Maximum Alignment Distance (Max Align Dist)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the maximum number of follower motor revolutions between the trigger inputs before an Alignment Fault will occur (P4-06).	Default: 1000 rev Min: 1 Max.: 5000
P4-08 (626) RUN	Maximum Alignment Speed (Max Align Speed)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the maximum follower speed allowed for an alignment to occur to prevent alignment at high speeds where accuracy is diminished. A setting of 0.0 Hz disables this function.	Default: 0.0 Hz Min: 0.0 Max.: 400.0
P4-09 (627) RUN	Align Trigger Window (Align Trg Window)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the maximum amount of alignment error allowed before the Window Counts increment (in follower revolutions). During an alignment check, if P4-09 is exceeded, the U7-13 Window Counts monitor is incremented. If the alignment error is equal to or less than the value set to P4-09, the U7-13 Window Counts monitor is decremented. Note: This parameter is only used when P4-01 is set to 4.	Default: 2.00 rev Min: 0.0 Max.: 100.0
P4-10 (628) RUN	Align Trigger Count (Align Trig Count)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Sets the number of Window Counts (monitor U7-13) required to trigger an alignment. Note: This parameter is only used when P4-01 is set to 4.	Default: 3 cnts Min: 1 Max.: 100

No. (Addr. Hex)	Name (Digital Operator Display)	Description	Values
P4-11 (629)	Repeat Trigger Select (Repeat Trig Sel)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Selects the method for handling triggers. 0: Last Trigger. If consecutive master triggers (or follower triggers) occur before a corresponding follower trigger (or master trigger) occurs, the last master trigger (or follower trigger) is used for alignment. 1: First Trigger. If consecutive master triggers (or follower triggers) occur before a corresponding follower trigger (or master trigger) occurs, the first master trigger (or follower trigger) is used for alignment. This option is identical to F7 functionality.	Default: 0 Range: 0, 1

◆ U7: Coordinated Motor Monitors

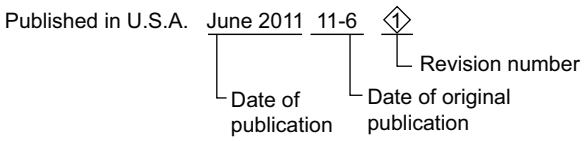
No. (Addr. Hex)	Monitor Name (Digital Operator Display)	Description	Analog Output Scaling	Unit
U7-02 (661)	Master Encoder Reference (Master PG Fref)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the frequency of the master encoder before gear ratios and MOP gains are applied. Note: Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-03 (662)	Follower Reference after Gear Ratio (Fref After Gear)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the frequency of the master encoder after the active gear ratio (P1-03 to P1-08) is applied. Note: Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: 100.00%	0.01%
U7-04 (663)	Gear Ratio Adjustment (Gear Ratio Adj)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the total gear ratio adjustment (sum of the digital, analog, MOP, and communication adjustments).	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-05 (664)	Follower Reference after Gear Ratio Adjustment (Fref After Adj)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the frequency of the master encoder after the digital, analog, MOP, and communication gear ratio adjustments are applied. Note: Display/Modbus values are limited to -3276.8 to 3276.7 <1>.	Full scale: Maximum Output Frequency (E1-04)	0.1 Hz
U7-06 (665)	Master Counts/5ms (Master Cts/5ms)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the number of quadrature encoder counts per 5 ms from the master drive. This monitor is representative only and should only be used to confirm that encoder counts are being received. Note: ELS modes only.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	cnts
U7-07 (666)	Follower Counts/5ms (Follower Cts/5ms)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the number of quadrature encoder counts per 5 ms from the follower drive. This monitor is representative only and should only be used to confirm that encoder counts are being received. Note: ELS modes only.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	cnts

No. (Addr. Hex)	Monitor Name (Digital Operator Display)	Description	Analog Output Scaling	Unit
U7-08 (667)	Position Error (Position Error)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the position error between the master and follower encoders in quadrature follower encoder counts. Note: ELS modes only. Note: Modbus values are limited to -3276.8 to 3276.7. Display values are limited to -9999 to 99999 <1>.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	P1-10 <2> <3>
U7-09 (668)	Position Regulator P Output (Position P Out)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the proportional gain contribution of the position PI regulator. Note: ELS modes only.	Full scale: 100.00%	0.01%
U7-10 (668)	Position Regulator I Output (Position I Out)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the output of the integrator of the position PI regulator. Note: ELS modes only.	Full scale: 100.00%	0.01%
U7-11 (668)	Position Regulator PI Output (Position PI Out)	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the output of the position PI regulator. Note: ELS modes only.	Full scale: 100.00%	0.01%
U7-12 (66C)	Alignment Error Alignment Error	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the Alignment Error seen during the last Alignment Check in follower revolutions. During default conditions with a forward Run command, a positive Alignment Error means that the master is too far ahead of the follower.	Full scale: Counts/5 ms at Maximum Output Frequency (E1-04)	revs
U7-13 (66D)	Alignment Window Counts Window Counts	V/f V/f w PG OLV CLV OLV/PM AOLV/PM CLV/PM Displays the current count of Alignment Checks that have been outside of the P4-09 alignment window when P4-01 is set to 4. This monitor resets and an alignment is performed when this count is reaches the value of P4-10.	n/a	n/a

<1> When the internal value is outside of the maximum/minimum value range that can be displayed on the keypad, the monitor will display the maximum/minimum value and the display name of the monitor will flash, alternating between “OVER” and the monitor name.
<2> Unit is dependent on the setting of the Position Units Selection (P1-10).
<3> When reading by network communication (register 667), the unit is fixed at quadrature encoder counts.

◆ Revision History

The revision dates and the numbers of the revised manuals appear on the bottom of the back cover.



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